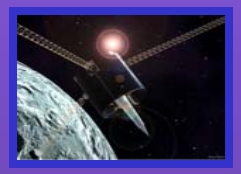
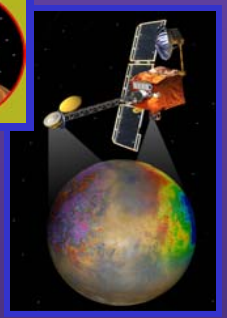
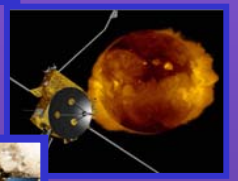
RESOURCE ALLOCATION REVIEW BOARD

August 12, 2003







Agenda

• INTRODUCTION	P. Doms	8:30
• OVERVIEW, CONTENTION SUMMARY	G. Burke	8:40
• NASA HEADQUARTERS PERSPECTIVE – CODE S	C. Holmes	8:50
• JPL DSMS ENGINEERING PROGRAM OFFICE	K. Kimball	9:30
• JPL DSMS OPERATIONS PROGRAM OFFICE	J. Hodder	9:50
– Mid-Term Scheduling Process Changes	K. Riley	10:00
• NEW OR MODIFIED PROJECT REQUIREMENTS		
– Mars Reconnaissance Orbiter	R. Zurek	10:10
– SOHO Requirements	Bush/Mahmot	10:30
• RESOURCE CONTENTIONS		
– Analysis & Recommendations	N. Lacey	10:50
– Responses	Projects	
– Discussion / Decisions	All	
• NEW ACTION ITEMS & SUMMARY	G. Burke	

Review Board Members

Peter Doms	JPL	Chairman
Gene Burke	JPL	Resource Allocation Planning & Scheduling Office Mgr
Claudia Alexander	JPL	ROSETTA U.S. Project Manager
Donald Burnett	Caltech	Genesis Project Scientist
Albert Chang	JPL	Nozomi, Lunar-A Project Representative
Alan Cummings	Caltech	Voyager Project Scientist Representative
Bob Farquhar	APL	MESSENGER, New Horizons Project Representative
Tom Fraschetti	JPL	DAWN Project Manager
David Gallagher	JPL	SIRTF Project Manager
Roger Gibbs	JPL	Mars 2001 Odyssey Project Manager
Jim Graf	JPL	Mars Reconnaissance Orbiter Project Manager
Richard Horttor	JPL	Mars Express Orbiter U.S. Project Manager
Ken Kimball	JPL	DSMS Engineering Program Office Representative
Mike Klein	JPL	Radio Astronomy Project Manager

Review Board Members

Ron Mahmot	GSFC	Space Science Mission Operations Project Manager (SOHO, WIND, Polar, Geotail, Cluster II, ACE, Image, MAP)
Daniel Mandl	GSFC	ST-5 Project Representative
Ed Massey	JPL	Ulysses/Voyager Project Manager
Dennis Matson	JPL	Cassini Program Scientist
John McNamee	JPL	Deep Impact Project Manager
Rich Miller	JPL	DSMS Plans & Commitments Office Manager
Dan Ossing	APL	STEREO Project Representative
Steve Ostro	JPL	GSSR Project Scientist
Jeff Plaut	JPL	Mars 2001 Odyssey Mission Project Scientist
Ken Riley	Lockheed	CSOC JPL Site Manager
Bob Ryan	JPL	Stardust Project Representative
Dave Seal	JPL	Cassini Program Representative

Review Board Members

Rance Skidmore	Omitron	GOES Project Representative
Martin Slade	JPL	GSSR Project Manager
Joel Smith	JPL	Muses-C, U.S. Space VLBI Project Manager
Don Sweetnam	JPL	Genesis Project Manager
Pete Theisinger	JPL	Mars Exploration Rover Project Manager
Tom Thorpe	JPL	Mars Global Surveyor Project Manager
Phil Varghese	JPL	Planetary Flight Projects Mission Management Office
Joe Wackley	JPL	DSMS Operations Office Program Manager
Steve Waldherr	JPL	INTEGRAL Representative
Brent Williams	SAO	Chandra Project Representative
Lincoln Wood	JPL	Reference Frame Calibration Project Manager
Richard Zurek	JPL	2001 Mars Reconnaissance Orbiter Project Scientist

Welcome and Introduction

Deep Space Mission System

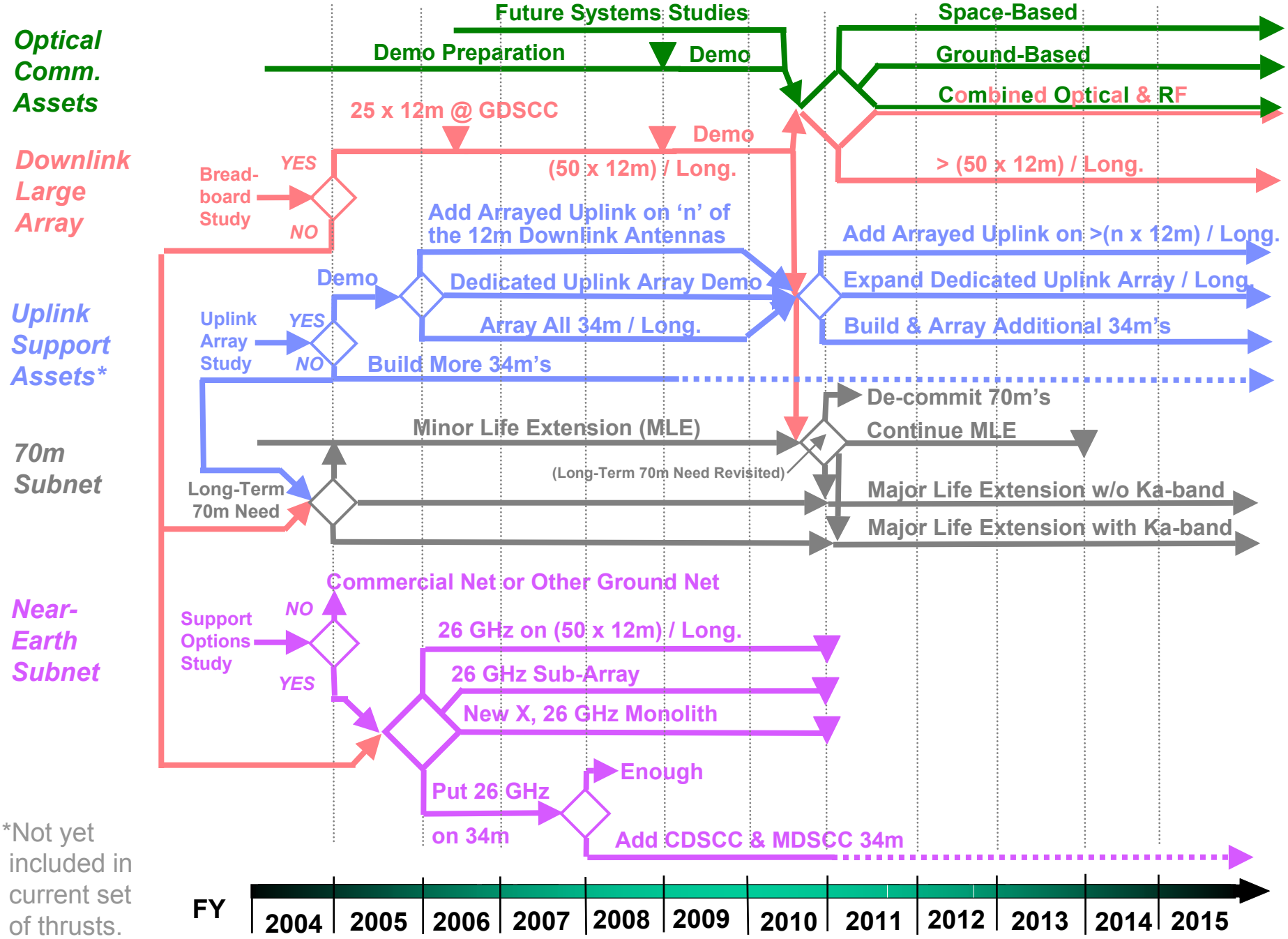
Peter Doms
Program Manager

JPL

Agenda

- Welcome
- Long-Range Plan & Key Decisions for DSMS Assets: Baseline
  - Decisions
  - Thrusts
  - Reviews
    - Executive Management Board – June 17-19, 2003 (Code SE)
    - DSMS Operations Assessment Board – August 18-20, 2003 (Code S)
- New DSN O&M Contractor
- 03/04 Operations Readiness Review – October 22-23, 2003
- Mid-Term Scheduling Process

Long-Range Plan & Key Decisions for DSMS Assets: Baseline



*Not yet included in current set of thrusts.

Thrusts Summary (Cont'd)

	Thrust	Example Capabilities	Dependency on Other Thrusts
1	Reliable DSN service provision	Robust hardware and software with high functional availability, faster fault detection, isolation and recovery (FDIR), reduction of setup time, service visibility, service accountability.	
2	DSCC Facilities Improvements	Upgrades or replaces existing facilities to enable greater efficiency.	
3	Operational Ka	Add Ka-band to 34m BWG antennas & test facilities. Prepare for telemetry service using historical statistics, manual antenna calibration, selective retransmission, and simple operations concepts.	7, 10, 11
4	Ka on 70m Subnet	Add X/X/Ka feeds, Multi-Cavity Maser (MCM) LNAs to 70m stations	3
5	Ka Tracking & Navigation	Implement a wideband front-end for Delta-DOR. Implement Ka-band range, Doppler, and angular measurements. Add Ka-band uplink on the BWG antennas.	3, 20
6	Advanced Tracking Stations for Category-A Missions	Replace obsolete components, e.g. MFR, in the 26m stations. Add X-band to 26m stations or equivalent.	
7	High Rate Telemetry	AOS frames with frame retransmission protocol, increased acquisition throughput at 10-20 Mbps for deep space 40-100 Mbps for high Earth, increased Turbo decoder throughput, LDPC code, 26-GHz Ka downlink	10, 11
8	DSN Large Array	Complete a 70m equivalent array at each longitude for operational demonstration in 2009.	3, 5
9	Optical Communications	Flight optical communications capability: 200-400 nrad rms laser pointing, high-efficiency lasers for Mbps- Gbps optical links. Ground-based receivers (antennas, detectors, receivers, decoders).	7
10	Interoperable Services	Develop CCSDS standards for space link, coding and modulation, proximity link, on-board interfaces, SLE service management, security/privacy, XML data packaging and registry, etc.	9, 22

Thrust: fully funded in POP'03 Thrust: Partially funded in POP'03 Thrust: Not funded in POP'03

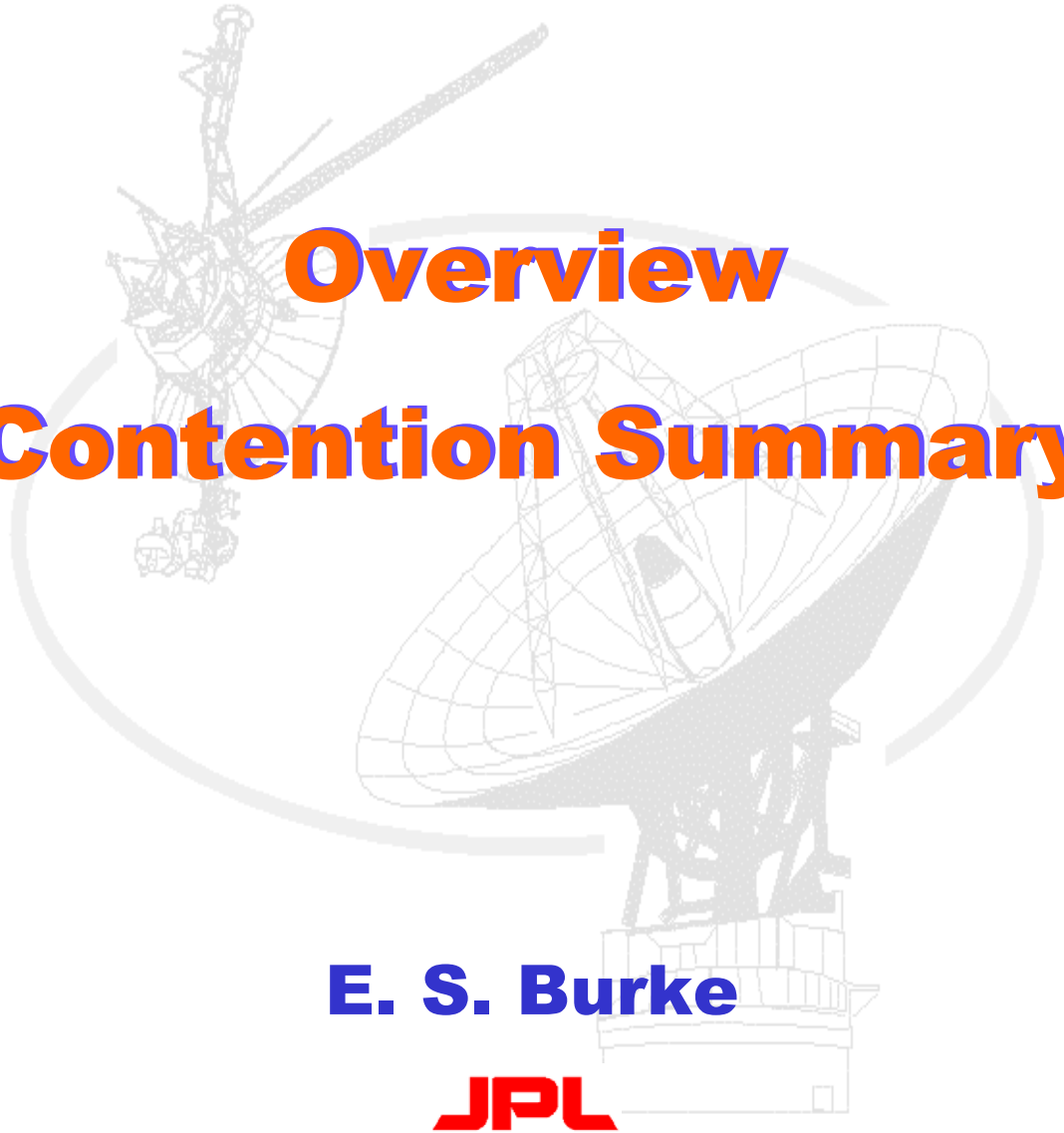
Thrusts Summary (Cont'd)

	Thrust	Example Capabilities	Dependency on Other Thrusts
11	Wideband Ground Communications	Increase line bandwidth between DSN ground stations and JPL to 45 Mbps using T3 circuits. Provide security for mission-critical data.	
12	Flexible Test Infrastructure	Augment TSA2; Test automation tools; DTF-21 replenishment; DSS-13; RF stability diagnostic tool for radio science; DSN simulator	
13	Web-based GDS	Secure and reliable web, portal, registry and application servers as a common multi-mission platform for GDS tools and services.	
14	Science Product Services Initiative	Implement the Experiment Product Delivery Service for MRO & Kepler initially. XML data description for generic EDR generation.	1, 10
15	Trajectory Design Tools	Re-engineer mission analysis tools for low-thrust trajectory, small-body orbit, EDL, aerobraking, vehicle breakup, & multi-vehicle trajectory for multi-mission needs. Use modern software technology.	16
16	Next Generation Navigation Tools	Integrated tool-kit for navigation planning and design, trajectory estimation and control, and dissemination of trajectory knowledge.	15
17	Reusable Spacecraft Control Framework	Next generation mission planning and sequencing tools; VML II; reusable mission patterns; integrated planning/scheduling engines	
18	Evolution/Infusion of GDS Tools for Reuse	Continuous adaptation of existing GDS tools. Continuous infusion of third-party GDS tools into multi-mission tool set.	
19	Evolution/Improvements in DSN Science	Acquire VLBI Mark-V data recorders. Improve radar range resolution for near-Earth asteroids (NEA) using chirp technique for GSSR.	
20	Spacecraft Communication Components	100-W Ka-band power amplifier, 7-m inflatable antenna, advanced RFIC transponder and in-situ radios, highly stable miniature atomic-ion oscillator.	5
21	Technology for Future Thrusts	[A planning wedge for low-TRL, future technologies.]	
22	Mars Telecommunications	Integrated Mars relay/DSN operations. Improved MSPA scheduling tools, precision tracking techniques based on multi-s/c radio tracking observables, Mars Network Service Request Processor.	7, 10, 11, 13, 14 17, 18, 20, 24

Thrusts Summary (Cont'd)

	Thrust	Example Capabilities	Dependency on Other Thrusts
24	Future Navigation Paradigm	Technology to achieve order of magnitude more accurate landings on small bodies. Autonomous guidance and navigation algorithms for Entry, Descent, and Landing (EDL), aeromaneuvering, etc.	
25	Education Partnerships	Transform DSS-28 at Goldstone into a GAVRT education asset for student control of the antenna. Provide "Museum Alliance" service to the public.	

Thrust: fully funded in POP'03 Thrust: Partially funded in POP'03 Thrust: Not funded in POP'03



Overview

Contention Summary

E. S. Burke

JPL

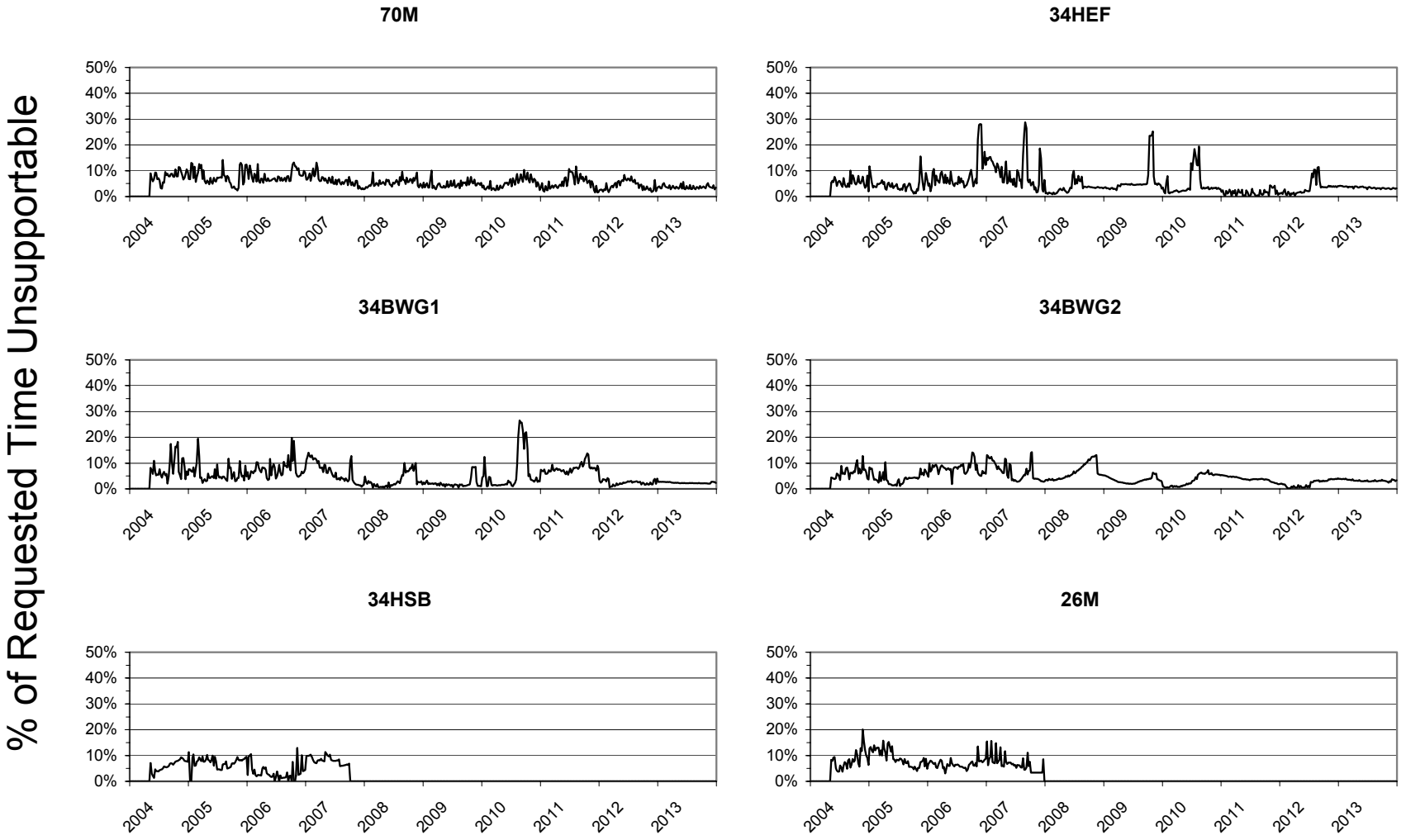
Introduction

- Welcome To The Resource Allocation Review
  - Board was Established to Provide Control of Tracking Requests 26, 34, & 70-Meter Subnets
  - Recommend Resource Allocation and Assist in Capacity Planning
- Requirements 2004 Through 2013
- Conflicts in 2004 Through 2006 Needing Resolution

Contention Resolution Process

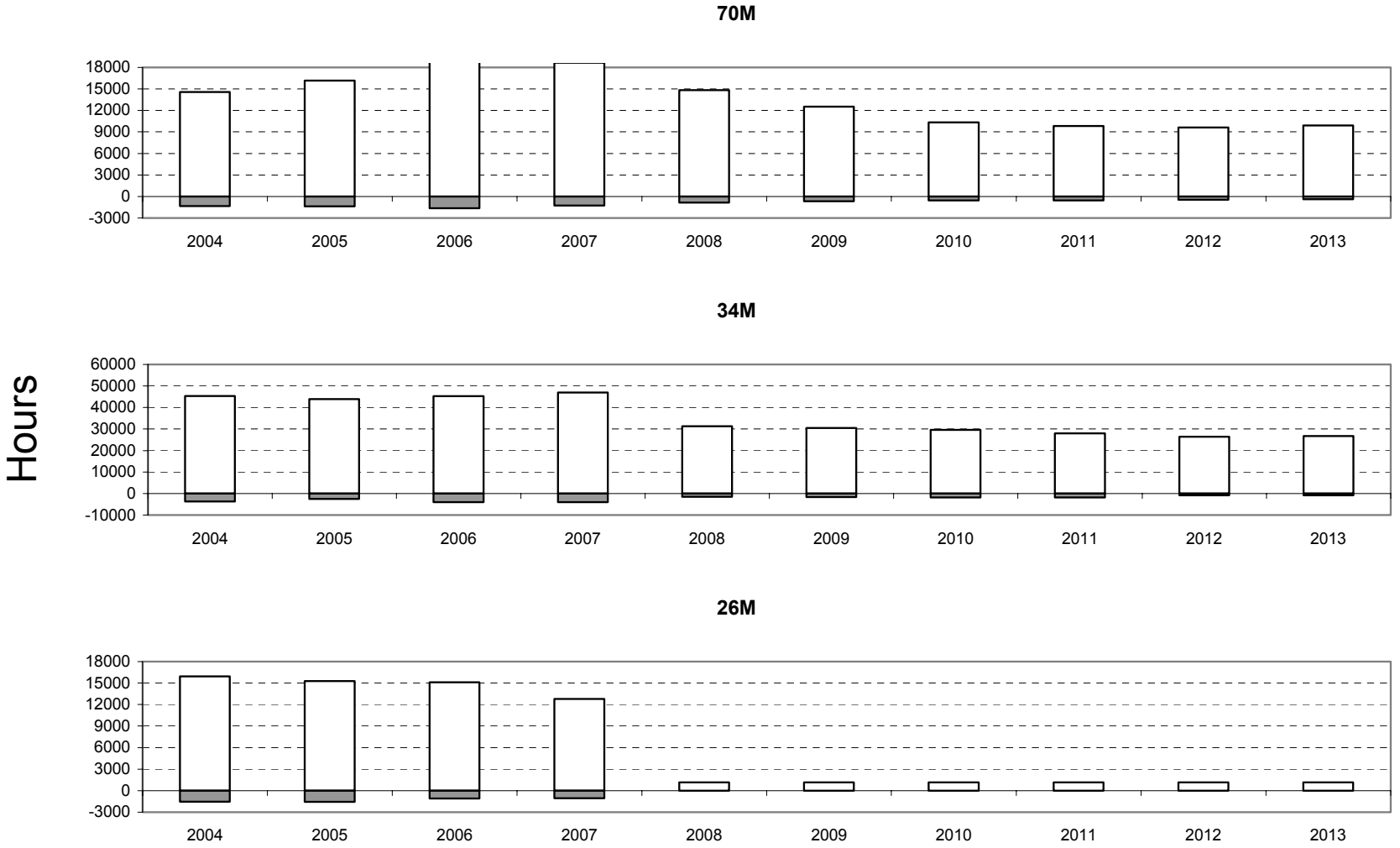
- Contention Explanation
- Resource Analysis Team (Rat) Recommendations
- Project Response To Recommendations
- Review Board Discussions
- Review Board Decisions

Projected Unsupportable Time Summary



$$\text{Projected Unsupportable Time} = \frac{\text{Total Expected Unsupportable Time}}{\text{Total Requested Resource Usage Time}}$$

Projected Yearly Supportable Time Summary



Unshaded Area = Supportable
Shaded Area = Unsupportable

Action Item Status From February 11, 2003 RARB

David G. Morris

JPL

Action Item Summary

AI#	Year	Month(s)	System	Responsible	Due Date	Status
01	2003-2004	December-April	Mars Program	B. Arroyo	06/01/2003	Pending

ACTION: (aka 8/13/02 RARB A.I. #7) Multi-mission DSN Allocation and Planning (MDAP) provide a Mars Program coordinated input to Resource Allocation (Mid-Range) Planning Team (RAPT) of at least one week per week at least 6 months prior to the schedule week. This action will use the result of Action Item 6 (of 8/13/02 RARB) to clarify the scope of resources in which to plan to.

RESPONSE: (8/4/03) Present status: Weeks in December 2003 plus January 2004 are delivered.

AI#	Year	Month(s)	System	Responsible	Due Date	Status
02	2004	October-December	RAPSO	S. Lineaweaver	04/20/2003	Closed

ACTION: Analyze proposed DSS-45 downtime (10/18/2004 – 12/05/2004) for Antenna Controller Replacement (ACR) and Microwave Switch Controller (USC).

RESPONSE: (3/20/03) Presentation of contention analysis approved at March 2003 JURAP meeting.

Action Item Summary

AI#	Year	Month(s)	System	Responsible	Due Date	Status
03	2005	April-May	Cassini	D. Seal	02/25/2003	Closed

ACTION: Provide Cassini Occultation Plans regarding DSS-25 planned downtime.

RESPONSE: (02/18/03) Information provided showed Cassini's need for DSS-25 prior to February 19 and after April 30.

AI#	Year	Month(s)	System	Responsible	Due Date	Status
04	2005	July-August	Mars Express	T. Thompson	04/10/2003	Closed

ACTION: Provide impact to Mars Express requested weekly Bi-Static Radio Science requirement during planned DSS-43 downtime.

RESPONSE: (2/19/03) Mars Express requests that the Bi-Static experiments be moved to another 70M antenna in each week that DSS-43 is down. When using another 70M antenna, continue to use the same 70M antenna for several weeks versus having DSS-63 one week and DSS-14 the next

News from Office of Space Science

Dr. Charles P. Holmes
Sun-Earth Connection Division

Topics:

- 2004 Appropriation
- Phoenix Mission selected
- Recommendation for Ulysses extension
- Science Prioritization Board
- Australia visit
- DSMS Assessment Board

Status of the 2004 Appropriations Bill

- The House passed the 2004 VA/HUD appropriation bill on July 25 and sent to the Senate:
  - $7,707M for Science, Aeronautics and Exploration in fiscal year 2004. The amount recommended is an increase of $47M to the budget request, and an increase of $303M to the fiscal year 2003 level as estimated in this new account structure.
  - Appears to have adopted the 'full cost accounting' provision in the President's budget request.
  - Numerous 'ear marks' including significant reductions to New Frontiers, JWST, SIM, etc.
- Congress is currently in recess until September
- September agendas include:
  - Senate appropriations committee markups
  - Full Senate vote/amendment
  - Conference committee settles differences

First Scout Mission Selected for 2007 Launch

Phoenix, an innovative and relatively low-cost mission, to study the red planet, as the first Mars Scout mission.

- Designed to land in the high northern latitudes of Mars, will follow-up on Mars Odyssey's spectacular discovery of near-surface water ice in such regions.
- It will land in terrain suspected of harboring as much as 80 percent water ice by volume within one foot of the surface, and conduct the first subsurface analysis of ice-bearing materials on another planet.

NASA Recommends an Extension of Ulysses Until March 2008

- The SEC science theme holds biannual reviews of the science programs of the operating missions:
  - Results were announced last week
- Will permit the third polar pass of the Sun - but without ‘full time’ uplink coverage for nutation control
- ESA’s funding process to decide by late fall

Science Prioritization Board

- Established to provide prioritization to DSMS on allocations of the DSN during the Nov 2003 - Feb 2004
  - Preparing for contingency or emergency operations
- Fourth meeting held in July at HQ
  - A preview of the RARB conflicts
  - Reps from the OSS science themes, the HQ Mars division, and the RAPSO

HQ Program Executive Visited Australia in July

- Tidbinbilla
  - Good progress in upgrades and training
  - On-track to be ready to provide full support for Mars activities
- Parkes
  - Extension of X-band capability complete [43 to 55m]
  - Should pick up a factor of 2 in sensitivity with the dish extension, new tapered feed, and receiver
  - DSMS PE tested in a VLBI session on July 29-31
  - The RX and feed horn to be installed in the next couple of weeks

X-band Extension to the Parkes Radiotelescope

DSMS Assessment Board

- Code S has established an “independent” Board to assess:
  - the reliability of the existing DSMS and its ability to meet current mission commitments
  - the investment required in the DSMS to meet mission commitments throughout this decade.
- Meet at JPL on Aug 18 - 20.
- An opportunity to “rebalance” the DSMS budget as a result of the Code M to Code S budget transfer.

JPL Deep Space Mission System (DSMS)

Engineering Program Office (940)

K. R. Kimball

For J. I. Statman

JPL

Agenda

- Tasks recently completed
- Tasks to be completed before the 03-04 heavy loading
- Tasks to be completed after the 03-04 heavy loading

Consult your TMS Manager for details of schedule and functional capabilities

Tasks recently completed

- 20 kW Transmitter on BWG
  - Operational at DSS-24, DSS-34, DSS-26
  - Upgrades to DSS-25 and DSS 54 are underway
- NSP (Network Simplification Project) V3.2.7
  - Operational at all BWG, HEF, 70m
- DDOR (Delta Differenced One-way Range)
  - Operational since 5/10/03
- X/X/Ka-Feed
  - Operational at DSS-26, since 4/1/03

Tasks to be completed before the 03-04 overload

- X/X/Ka-band feeds
- DSS-55
- 2-MSPA Automation
- Arraying at Overseas DSCC's
- Follow-on 20 kW installations
- NSP 4.1

X/X/Ka feeds

- WHAT:
  - Replace the X/X feeds at the BWG's with X/X/Ka-band feeds
- WHEN:
  - Operational at DSS-26
    - DSS 55 – 11/1/03
- IMPACT ON CUSTOMERS:
  - Ka-band downlink capability
  - Improved X-band BWG downlink sensitivity at X-band
    - 0.5-2.5 dB depending on the operations mode and reference antenna

DSS 55

- WHAT:
  - Add a new antenna, a 34m BWG at MDSCC
- WHEN:
  - "First light" achieved
  - Operational – 1/11/03
- IMPACT ON CUSTOMERS:
  - Additional capacity

DSS 55 – First Light – June 03

20 kW Txr's on BWG Additional Installations

- WHAT:
  - Replace the 4 kW X-band Txr's with 20 kW Txr's
- WHEN:
  - Last two installations are underway
- IMPACT ON CUSTOMERS:
  - Better uplink capability
    - Same as HEF
    - Simplifies scheduling (HEF-BWG trade)

2-MSPA Automation

- WHAT:
  - Simplify the operations to support the downlink from two (virtual) spacecraft that are in the same beam
- WHEN:
  - NMC/CS – Delta-DDR Scheduled for 8/7/03
  - NSS D3 – DDR Scheduled for 8/12/03
- IMPACT ON CUSTOMERS:
  - Additional effective capacity
  - Note limitations
    - **Only one uplink**
    - **Must have compatible RF characteristics**

Arraying at Overseas Stations

- WHAT:
  - Add arraying capability at MDSCC and CDSCC
- WHEN:
  - Acceptance testing is underway
  - Operational – August 03
- IMPACT ON CUSTOMERS:
  - Additional capacity, especially when the 70m antenna is busy
    - Are customers planning the usage?

Delta DOR

- WHAT:
  - Add a new navigation tool
    - Validates traditional radio-metric measurements
    - Enables better targeting
- WHEN:
  - Operational
- IMPACT ON CUSTOMERS:
  - Additional tool for the navigation teams
    - Navigation strategy should be refined/adjusted as needed

NSP 4.1

- WHAT:
  - Add Turbo code capability
  - Add ST-5 command capability
  - Misc anomaly fixes
  - BWG, HEF, 70m
- WHEN:
  - Transition to NSP 3.2.7 is complete – Thanks to all missions!
  - NSP 4.1 DDR scheduled for 9/3/03
- IMPACT ON CUSTOMERS:
  - Turbo code, a new capability, for all future low-moderate rate missions
  - Better coding gain, e.g. by 0.8 dB for a typical code, compared to MCD3

Tasks to be completed after FY03

- X/X/Ka-band feeds
  - For the remaining BWG
- Antenna controllers for the 70m and HEF
  - Will require significant downtime
- 70m refurbishment
  - Will require significant downtime

Summary

- We depend on the customers to:
  - Take advantage of the capabilities we have put in place
    - SLE, TDN's, arraying
  - Define what capabilities we should put in place
    - Beyond sustaining of current capabilities
  - Help us to select capabilities that are the least cost-efficient, and could be candidates for decommissioning
- Your input is priceless!

JPL DSMS
Operations Program Office (930)

J. A. Hodder

For J. A. Wackley

JPL

Maintenance and Operations (M&O) Contract Change

- All schedule milestones are being met for the new contract start on January 1, 2004
  - New Contractor Announcement Expected Mid-September
  - 3-Month Contractor Transition Period Begins October 1

Network Simplification Project (NSP)

- All Stations Were Transitioned to NSP by Mid-May
  - New Version (D4.1) currently in acceptance testing
    - New version includes correction of numerous anomalies and turbo code (first mission user – MESSENGER)
    - Acceptance testing going well so far
    - Deployment expected early September

Space Link Extension (SLE)

- Current SLE Project Users
  - INTEGRAL
  - MEX
  - Hayabusa
- Early SLE problems with INTEGRAL resolved
  - Residual problems with INTEGRAL are 26m subnet problems in general
- No SLE problems with MEX or Hayabusa

Preparation for the 03/04 Activity Contention Period (ACP)

- The Tracking Support Specialists (TSSs) initiated service in the NOCC on July 5
- The 70m Servo Rehab is now completed
- Maintenance is on schedule to accomplish all required major maintenance prior to October 1, 2003
- DSN Operations Working Group (DOWG)
  - Met May 7-8
  - Continuing to work on ACP preparation
- Logistic Operations Working Group (LOWG)
  - Met on May 6
  - Continuing to work on ACP preparation

Preparation for the 03/04 Activity Contention Period (ACP)

- A DSMS Triage Process document is near completion
  - The process provides additional DSMS Management oversight for real-time reallocation of antennas.
  - The plan is to release the document and conduct exercises by September 1.

Mid-Term Scheduling Process Changes

K. Riley
LOCKHEED MARTIN

DSMS Scheduling Process

- **Problem:**
  - Midterm Schedule Is Currently "Conflict Free" 8 Weeks in Advance
    - DSMS Commitment Is 8-12 Weeks
    - Some Projects Have a Very Strong Need for a "Conflict Free" Schedule 26 Weeks in Advance—need Is Near Term Impacting Support During Asset Contention Period
  - Projects Have Expressed Concern With Overall Scheduling Process

- **Problem Resolution:**
  - Address Near Term Issue: Provide and Maintain a "Conflict Free" Schedule 26 Weeks in Advance
    - Will Have DSMS and Project Scheduler Resource Impact
    - Will Require Close Teamwork Between Project Schedulers and DSMS
    - Goal: Have 26 Week "Conflict Free" Schedule Available by 1 Oct (Addresses Entire ACP Period)
  - Cooperatively Address Mid Term (After 1 Oct) Scheduling Process and Tools
    - Realign CSOC Resource Analysis Team and Scheduling Under Single Supervisor With End-to-End Process Responsibility
    - Support Joint Review by Projects and DSMS of Scheduling Process and Identify Roadmap to Improve Process and Tools
  - Cooperatively Identify and Implement Longer Term Tools Needs
    - Establish Joint Project and DSMS Team to Assess Tools and Plan Near and Long Term Implementation Strategy

RESOURCE ALLOCATION REVIEW BOARD

Mid Term Scheduling Process Changes Near Term

- Preview Schedule Will Be For a 3 Week Period
- Preview Schedule Will Be Posted on Monday
- Project Schedulers Inputs Critical to Establish Baseline for Conflict Resolution

Raw "Preview" Schedule Posted
Week 1 Monday

→ **Project Schedulers Submit All Changes to Reflect Current Requirements**
Week 1 Friday

→ **"Conflict Schedule" Published**
Week 2 Monday

→ **Negotiation Meeting Unresolved Conflicts Identified**
Week 2 Friday

- Conflicts Worked During Week With Changes Submitted Via Email
- Only Unresolved Conflicts Will Be Discussed in Negotiation Meeting
- Meeting Will Be "Face to Face"
- "Tough Conflicts" Will Be Deferred

→ **RAPSO Facilitates Resolution With Schedulers (if needed)**
Week 3

→ **RAPSO Escalates Hard Conflicts (if needed)**
Week 4

→ **Conflict Free Schedule Published**
Week 5

Bottom Line

- Revised Process in Use
- Team Effort Needed for Success
- 26 Week Conflict Free Schedule by End of Sept

Scheduling Process Changes

- Mid Term
  - After 26 Week Conflict Free Schedule is Published, Negotiation Meeting will be Moved to Every 2 Weeks
- Mid/Long Term
  - Assess Entire Scheduling Process and Tools—Use Value Stream Mapping Technique
    - End-to-End Review by Stakeholders
    - Develop Desired “Future State”
    - Develop Roadmap to Achieve Future State
  - Event will be Conducted Week of September 29th
    - Championed by 930 and CSOC
    - Facilitated by Lockheed Martin Corporation
    - Participants should include representatives from
      - Project Schedulers
      - Resource Analysis Team
      - Scheduling Team
      - NOCC
      - Complexes

Status

- Near Term (Aug 1-Oct 1)
  - Process Change Implemented on 1 August
  - To Date: 6 Weeks of "Conflict Free" Schedule Have Been Produced
  - Management Controls Implemented to Monitor Plan Progress
- Mid/Long Term
  - Cooperative Team Effort by all Stakeholders Needed
  - Value Stream Mapping and Tools Teams Being Established
    - Pre-Planning Has Begun

Implementation of Enduring and Dramatic Process Improvement is Only Possible If All Stakeholders Are Involved in Identifying and Implementing Change—Without a Team Approach—Nothing is Sustainable

NEW OR MODIFIED PROJECT REQUIREMENTS

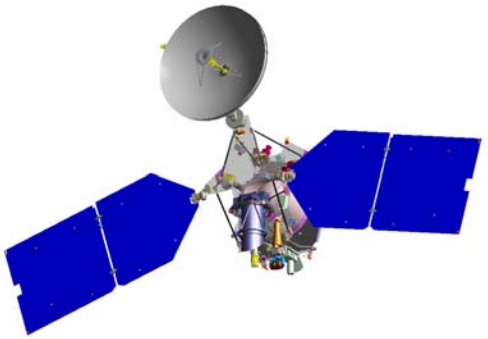
Mars Reconnaissance Orbiter

R. W. Zurek

JPL

Mars Reconnaissance Orbiter (MRO): The Next Step in Mars Exploration

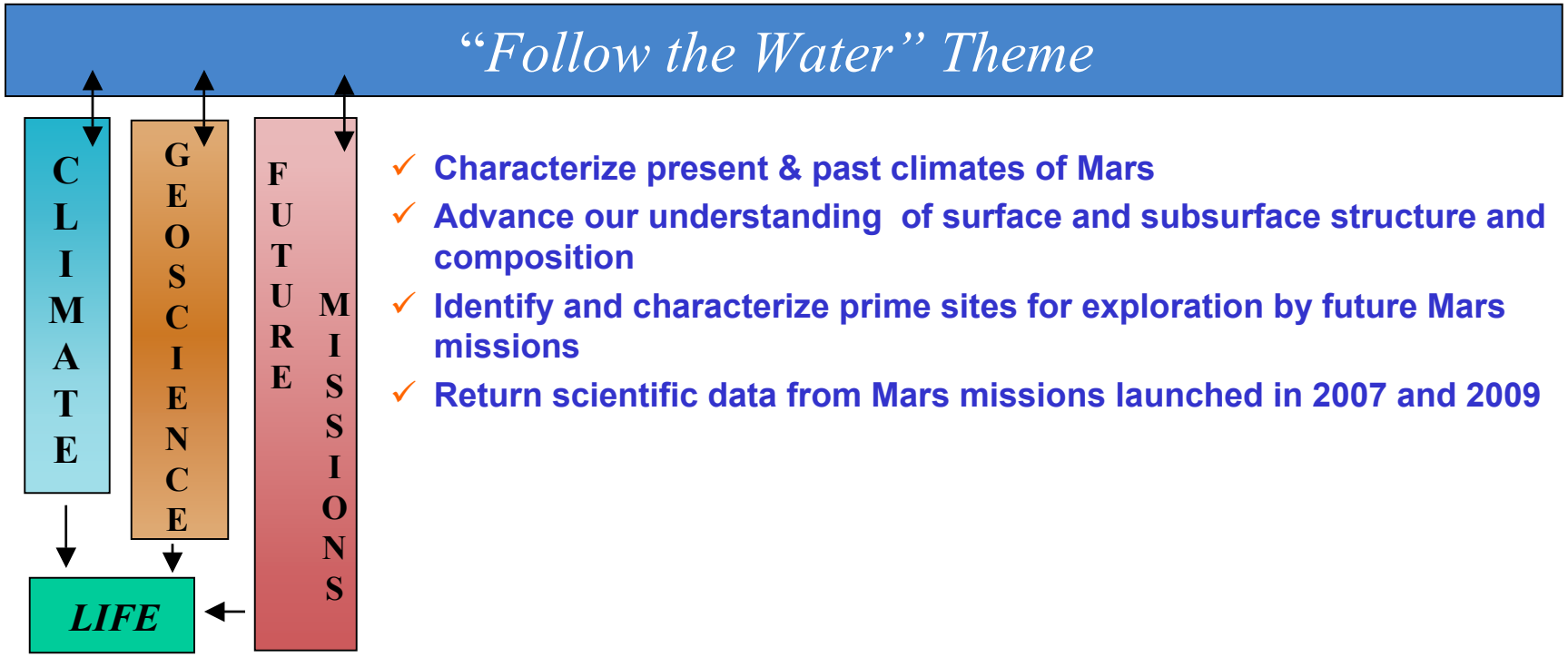
ATLAS V-401



MRO

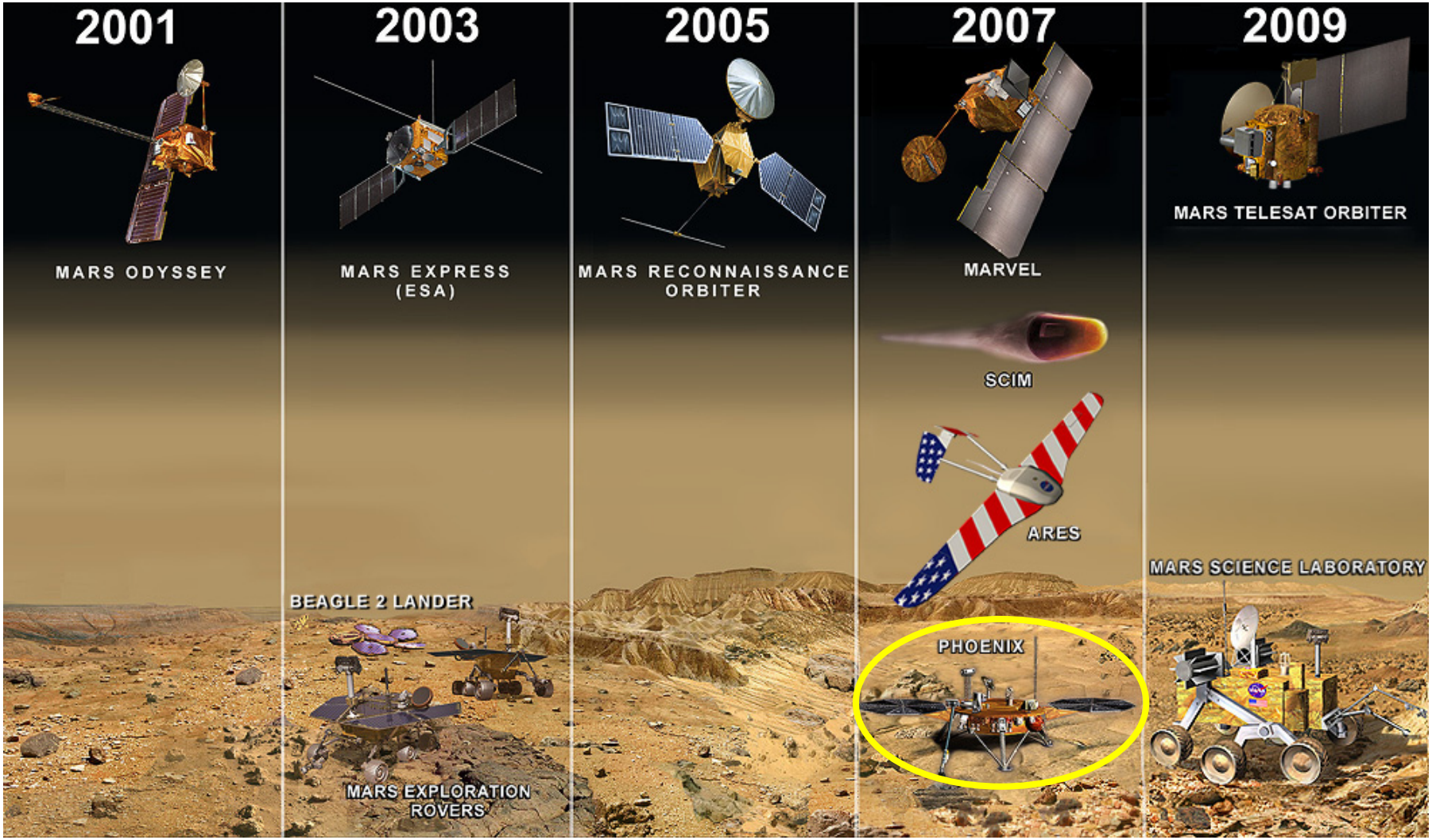
MRO Science Objectives

The Mars Reconnaissance Orbiter (MRO) Mission will make a major advance in our understanding of Mars in the context of the NASA Mars Exploration Program



- ✓ Characterize present & past climates of Mars
- ✓ Advance our understanding of surface and subsurface structure and composition
- ✓ Identify and characterize prime sites for exploration by future Mars missions
- ✓ Return scientific data from Mars missions launched in 2007 and 2009

Mars Exploration Program



Observe at Different Wavelengths

Observe at much Higher Spatial Resolution

MRO Payload Selection

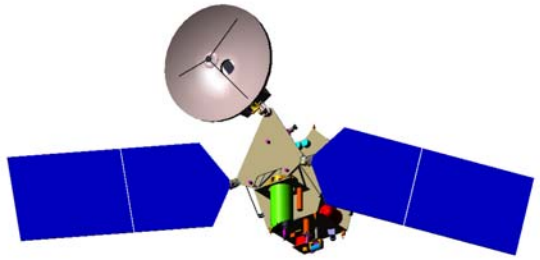
- **CRISM: Visible to Near Infrared Spectral Imaging in 512 spectral channels**
- **SHARAD: Shallow Sounding Radar (15-m wavelength in free space)**

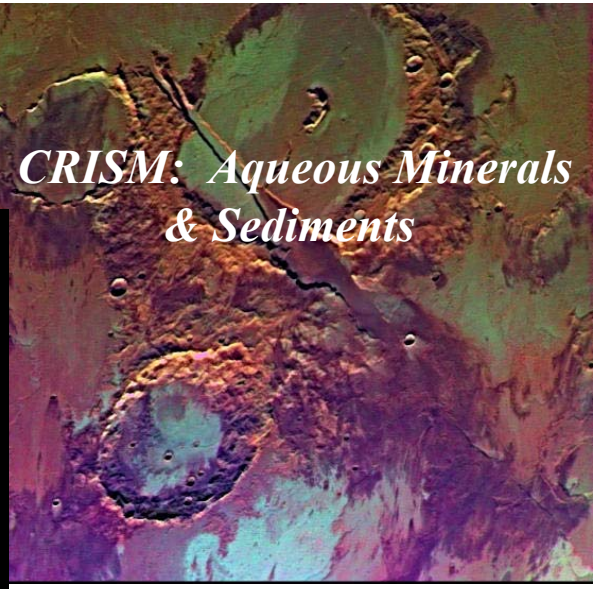
HiRISE: 1-meter resolution visible imaging
CTX: 6 m/pixel visible context imaging
CRISM: 20 m footprint spectral imaging
MCS: 5 km vertical profiling of atmosphere
MARCI: Daily global weather monitoring
SHARAD: ~10 m vert. resoln. to 0.5 km depth

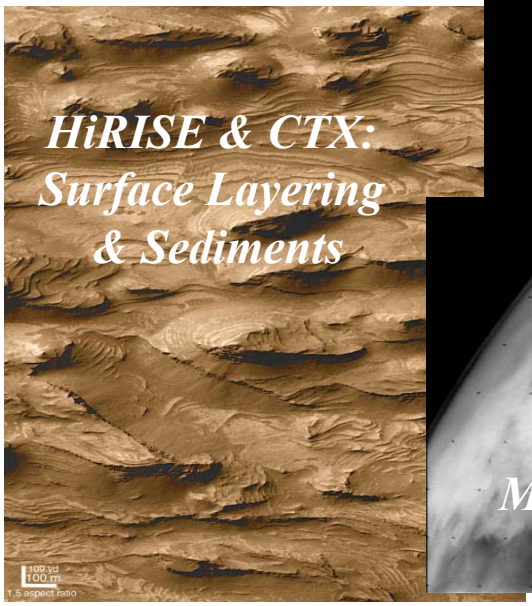
MRO Mission Design

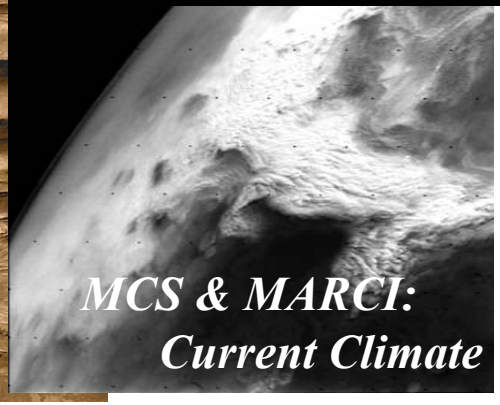
- **Must Return Large Data Volume (>26Tbits)**
- **Design Orbit for Coverage & Resolution**
  - **Near-Polar, 3 p.m./3 a.m.**
  - **255 km x 320 km**
- **Integrate Observation Modes:**
  - **Global Monitoring for 1 Mars Year**
  - **Regional Survey**
  - **Site Targeting with Precision**

MRO Spacecraft Design

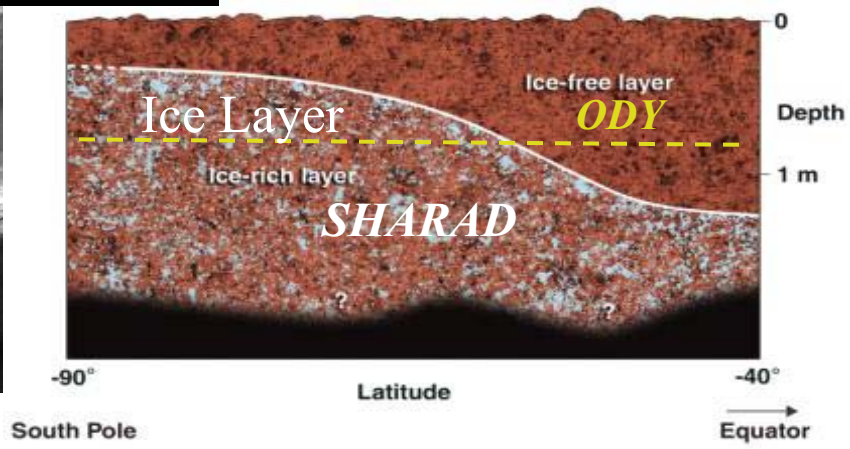




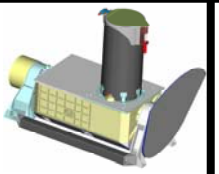
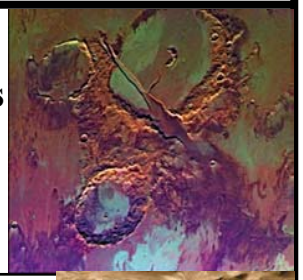
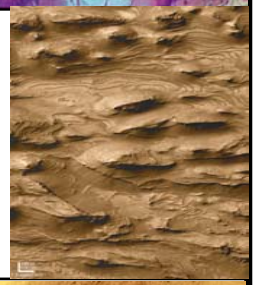
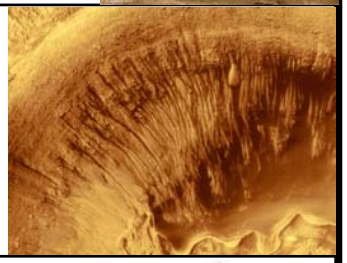
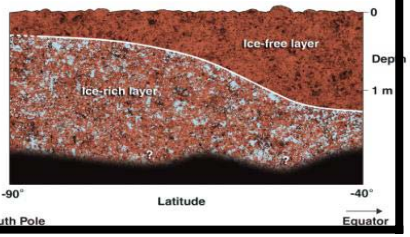




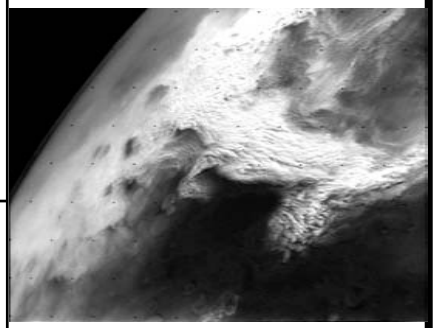
Subsurface Reservoirs

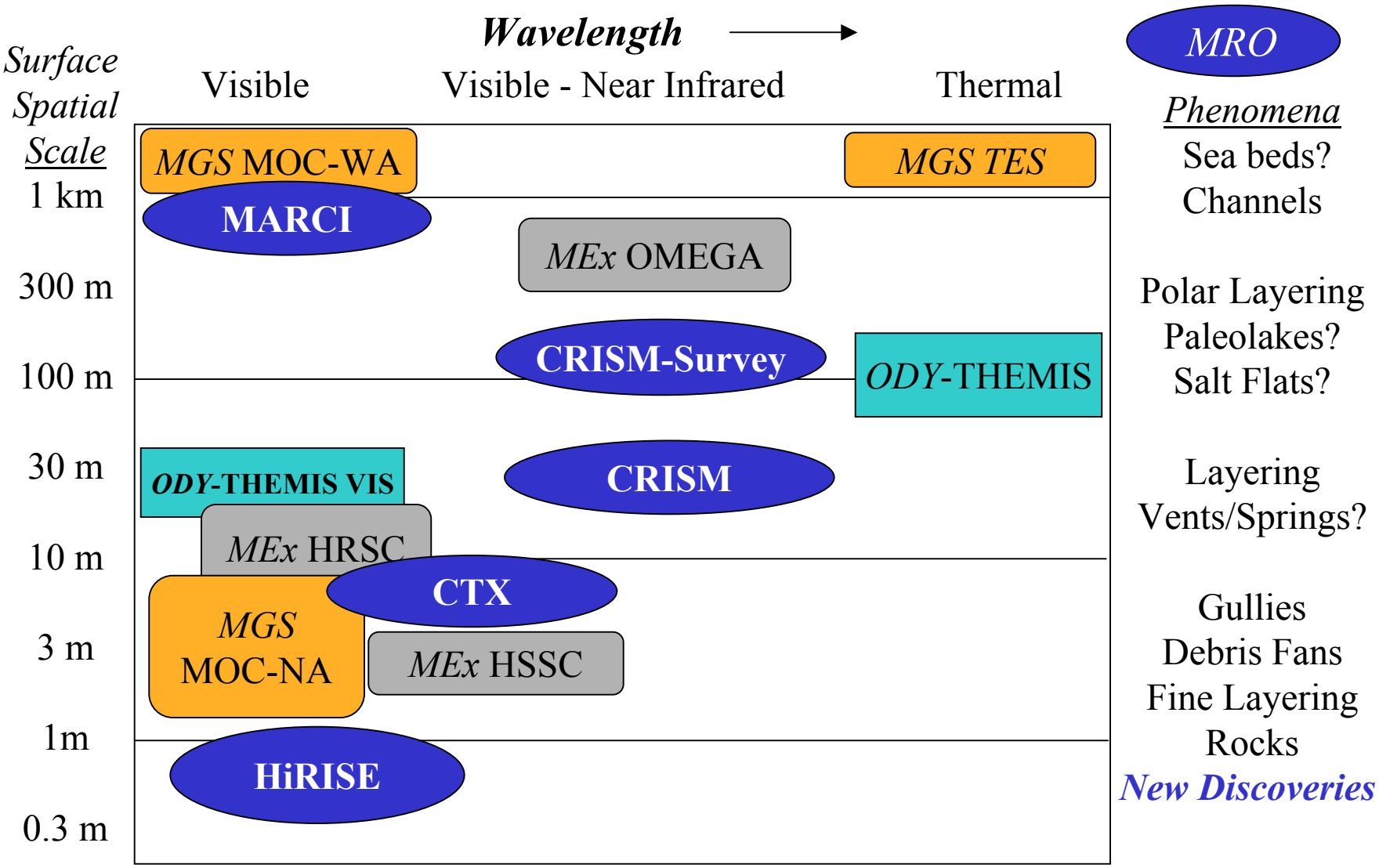


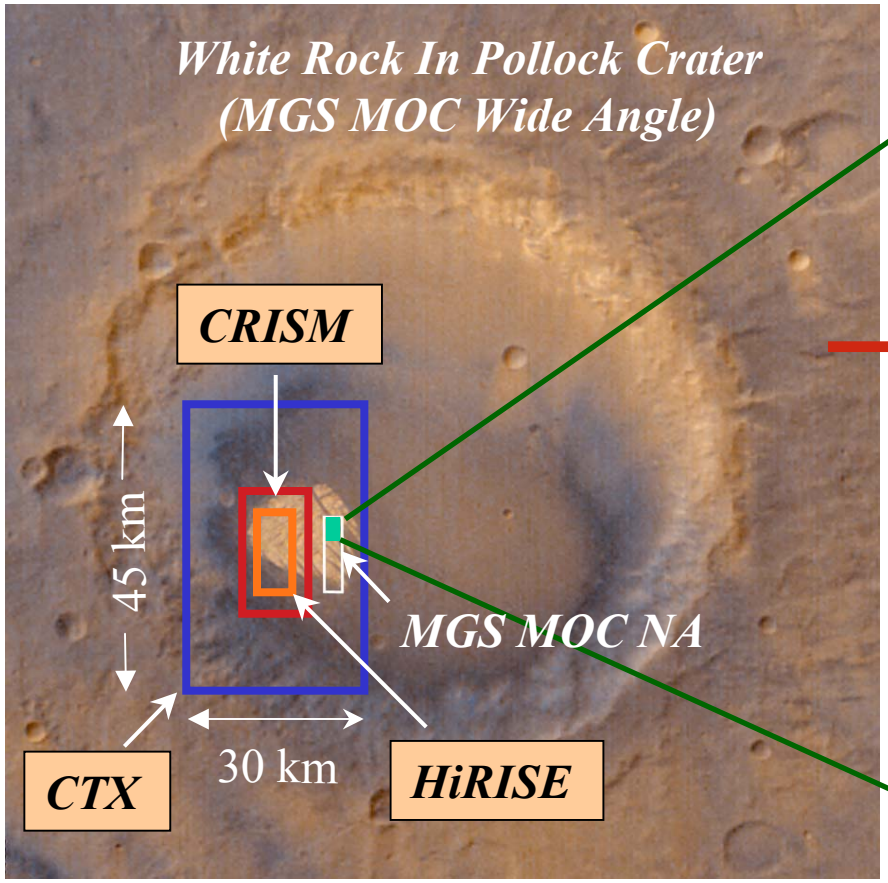
MRO Science Investigations (1 of 2)

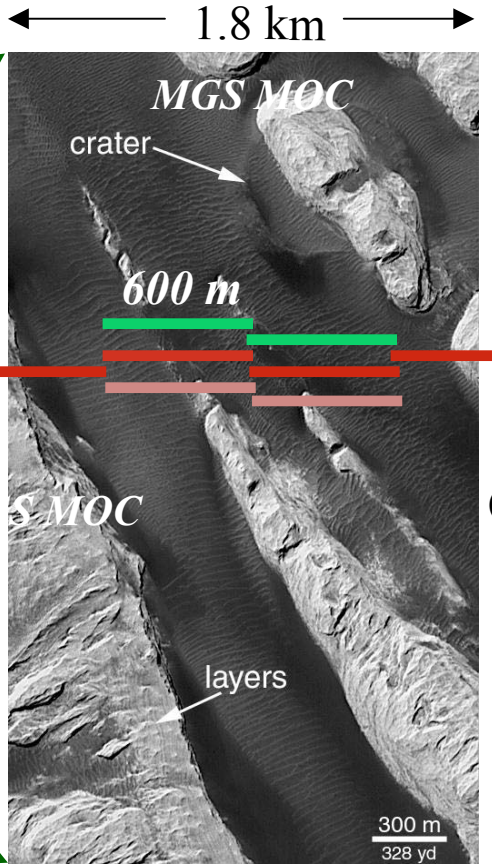
Instrument	*Type*	*PI/TL, Institution*	*Science Goals & Attributes*
 *CRISM*	Compact Reconnaissance Imaging Spectrometer for Mars	*Scott Murchie. PI* Johns Hopkins University Applied Physics Lab *Selected thru MRO -2005 AO*	**Surface Composition; Atmospheric Properties** GSD: 20 m/pixel Swath: 11 km COV: 100% @ 100-200 m/pixel 
 *CTX*	Context Imager	*Michael Malin, TL* Malin Space Science Systems (MSSS) *Facility Instrument* *Replaces MCO MARCI-MAC*	**Stratigraphy; Regional Morphology** GSD: 6 m/pixel Swath: 30 km COV: ~ 20% 
 *HiRISE*	High-Resolution Imaging Science Experiment	*Alfred McEwen, PI* University of Arizona *Selected thru MRO-2005 AO*	**Stratigraphy; Site Morphology** GSD: 0.3 m/pixel Swath: 6 km COV: ~ 1% 
SHARAD	Shallow Subsurface RADAR	*Roberto Seu, TL/PI* University of Rome *Roger Phillips, DTL* *NASA-ASI Selection*	**Regional Near-Surface Structure** 10 m vert. resoln. down to 0.5 km 

MRO Science Investigations (2 of 2)

Instrument	*Type*	*PI/TL Institution*	*Science Goals*	*Attributes*
 *MARCI*	Mars Color Imager	*Michael Malin, PI* Malin Space Science Systems *Recover MCO MARCI-WAC*	Global Weather and Surface Change	 **Daily Global Coverage Seasonal Cycles**
 *MCS*	Mars Climate Sounder	*Daniel J. McCleese, PI* Jet Propulsion Laboratory California Institute of Technology *Recover MCO PMIRR Science*	Atmos. Fields, Transport & Polar Processes; Seasonal Change	
Gravity Science	Facility Science Team Investigation	*Maria Zuber, TL* MIT / GSFC *Selected thru MRO-2005 AO*	Improved Gravity Field Model; transient Mass Change	**Data from DSN tracking using Spacecraft X & Ka Band Telecom**
Atmospheric Structure (ACCEL)	Facility Science Team Investigation	*Gerald Keating, TL* GWU / LaRC *Selected thru MRO-2005 AO*	Upper Atmospheric Structure & Variability; A/B Support	**Data from Spacecraft Accelerometers during Aerobraking**
Future	*Participating Scientists & Guest Observers may be selected and funded as part of a future Announcement of Opportunity or Research Announcement*			


Wavelength
Surface Spatial Scale
Visible
Visible - Near Infrared
Thermal
1 km
300 m
100 m
30 m
10 m
3 m
1m
0.3 m
MGS MOC-WA
MARCI
MEx OMEGA
MGS TES
CRISM-Survey
ODY-THEMIS
ODY-THEMIS VIS
CRISM
MEx HRSC
CTX
MGS MOC-NA
MEx HSSC
HiRISE
MRO
Phenomena
Sea beds?
Channels
Polar Layering
Paleolakes?
Salt Flats?
Layering
Vents/Springs?
Gullies
Debris Fans
Fine Layering
Rocks
New Discoveries





(1 of 10 HiRISE red CCDs arrayed crosstrack; 4 not shown)

Nested Coverage Provides Context

High Resolution Provides Detail

IMAGES from NASA/JPL/MSSS

RESOURCE ALLOCATION REVIEW BOARD

Jet Propulsion Laboratory
California Institute of Technology

2180 kg Launch Mass (Atlas V)

1545 m/s Delta-V

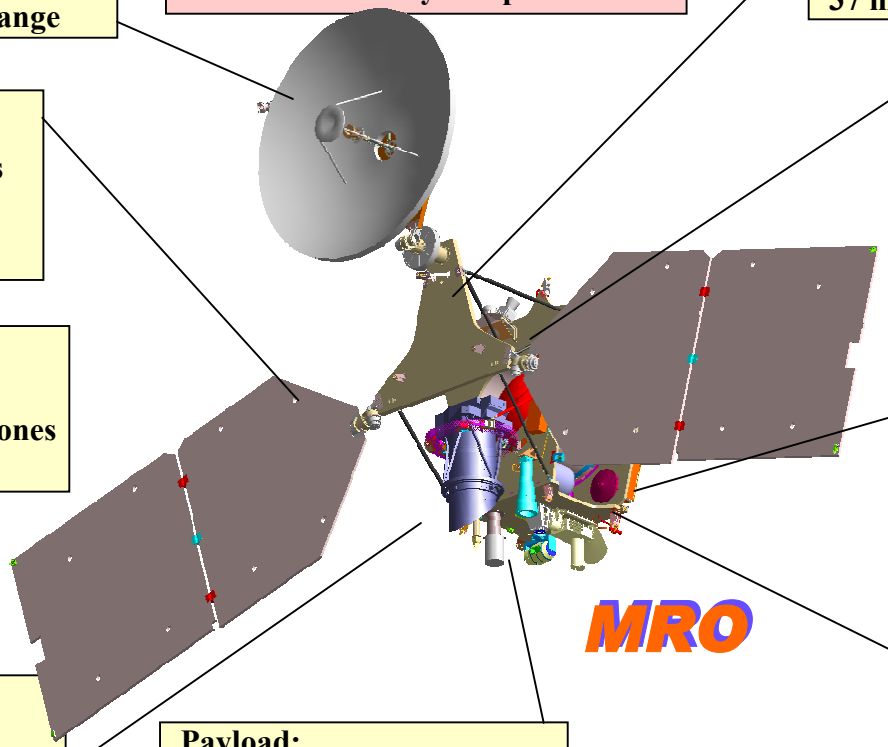
2000W Array at Aphelion

Telecom:
Dual X and Ka-Band Capability
3m HGA
Dual Fwd-Aft Tx/Rcv LGA
500 kbps @max earth Range

Structure:
M55J Composite Construction
Stiff Strut / Panel / Clip Design
Symmetric / Aero-Stable Design
37 m^2 AB Drag Area

EPS:
Dual 50 A-Hr NH_2 Batteries
20 m2 GaAs 3J Solar Cells
23% Margin at Aphelion

Mechanisms:
Redundant DC-Brushless Motors
16-Bit Resolvers
Redundant Release Mechanisms
> 2X Holding torque During MOI



Thermal:
Cold-Biased Passive Design
Largely FSW Controlled Htr Zones
200W Allocation

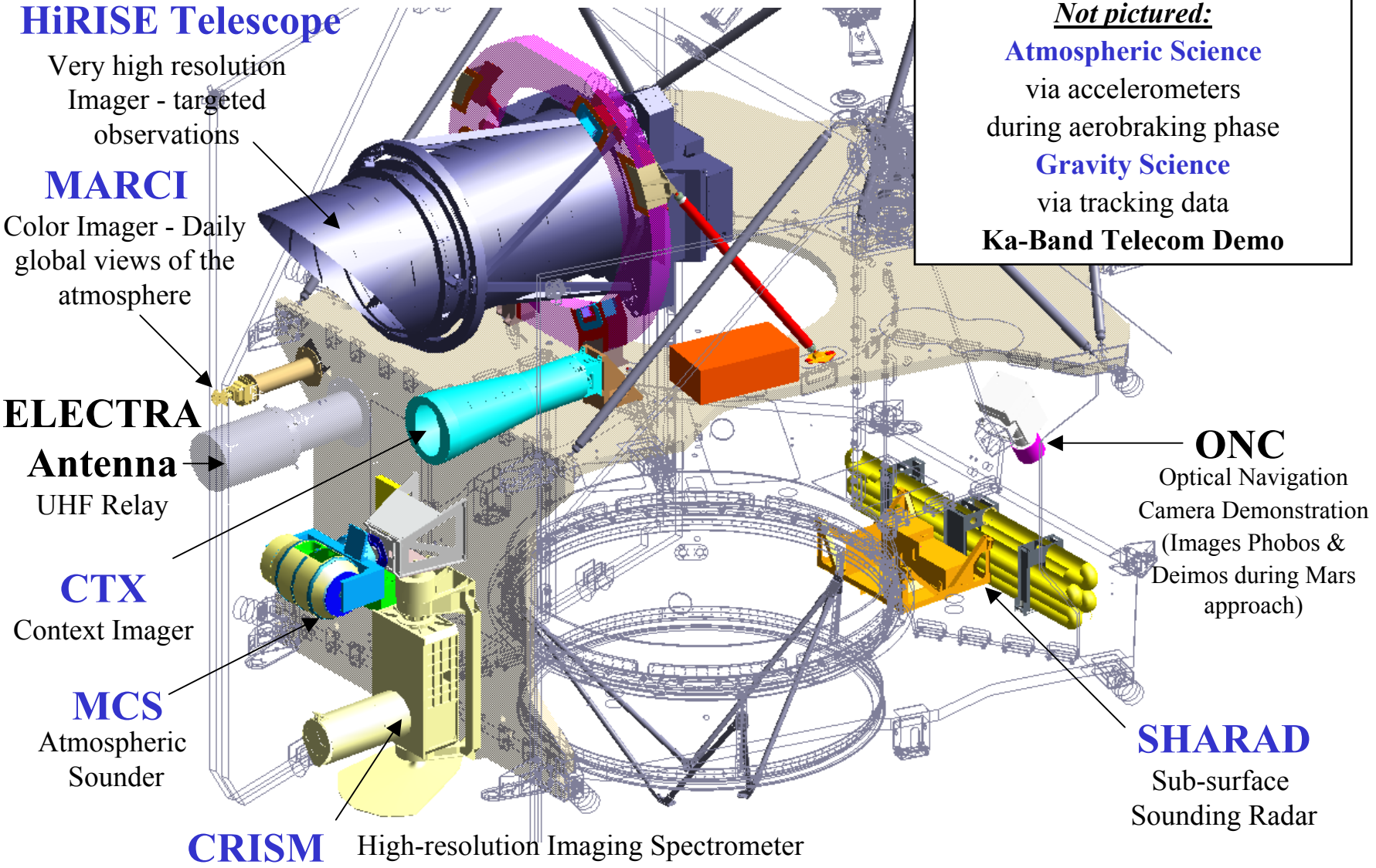
C&DH:
RAD750 FPC
160 Gbit SSR
Turbo or RS Encoding
100Mbps Science I/F

GN&C:
Redundant 100n-m-s RWA's
Ephemeris-Based Targeting
Cont/Auto Yaw Compensation
< 1 mrad Pointing Accuracy

Propulsion
Single-Tank Mono Prop Design
Engine-Out Capability
Coupled Thrust
Regulated During MOI

Payload:
6 Science Payloads
2 Eng Payload
Electra Eng SS
Simultaneous Operations
Nested Targeting

FSW:
Flexible / Parameterized Design
Fully Enabled Fault Protection
Ephemeris-Based Targeting
Time-Tagged Seq Fully Supported



HiRISE Telescope
Very high resolution Imager - targeted observations

MARCI
Color Imager - Daily global views of the atmosphere

ELECTRA
Antenna
UHF Relay

CTX
Context Imager

MCS
Atmospheric Sounder

CRISM
High-resolution Imaging Spectrometer

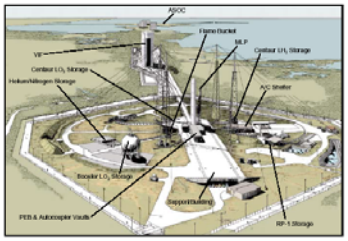
Not pictured:
Atmospheric Science
via accelerometers
during aerobraking phase
Gravity Science
via tracking data
Ka-Band Telecom Demo

ONC
Optical Navigation Camera Demonstration (Images Phobos & Deimos during Mars approach)

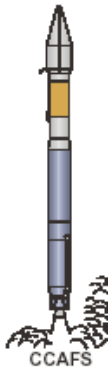
SHARAD
Sub-surface Sounding Radar

MRO Mission Overview

Launch
August 2005

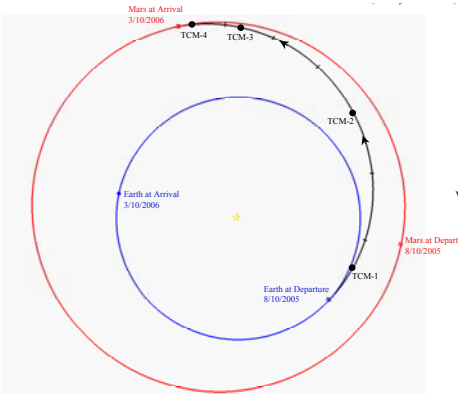


LC-41

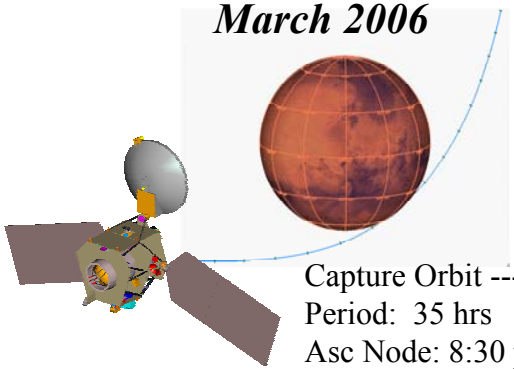


Atlas V-401

Interplanetary Cruise
Aug 2005 - Mar 2006

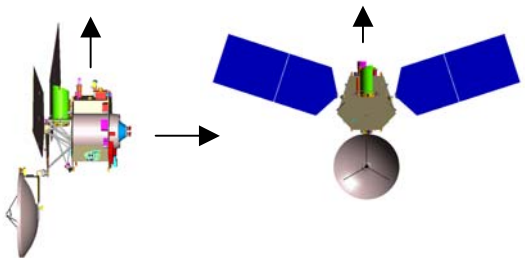


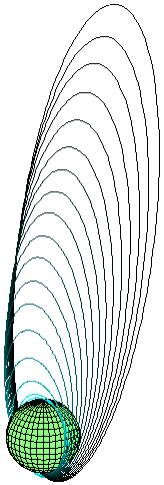
Approach and Orbit Insertion
March 2006



Capture Orbit ---
Period: 35 hrs
Asc Node: 8:30 pm LMST

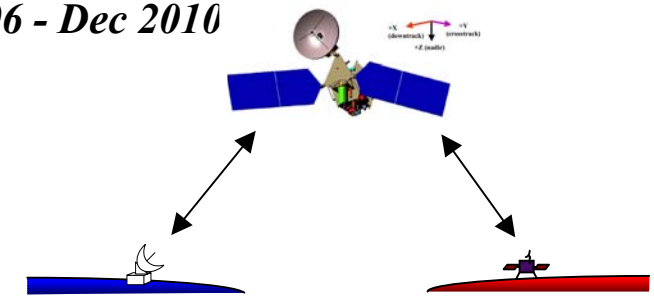
Aerobraking
Mar-Nov 2006





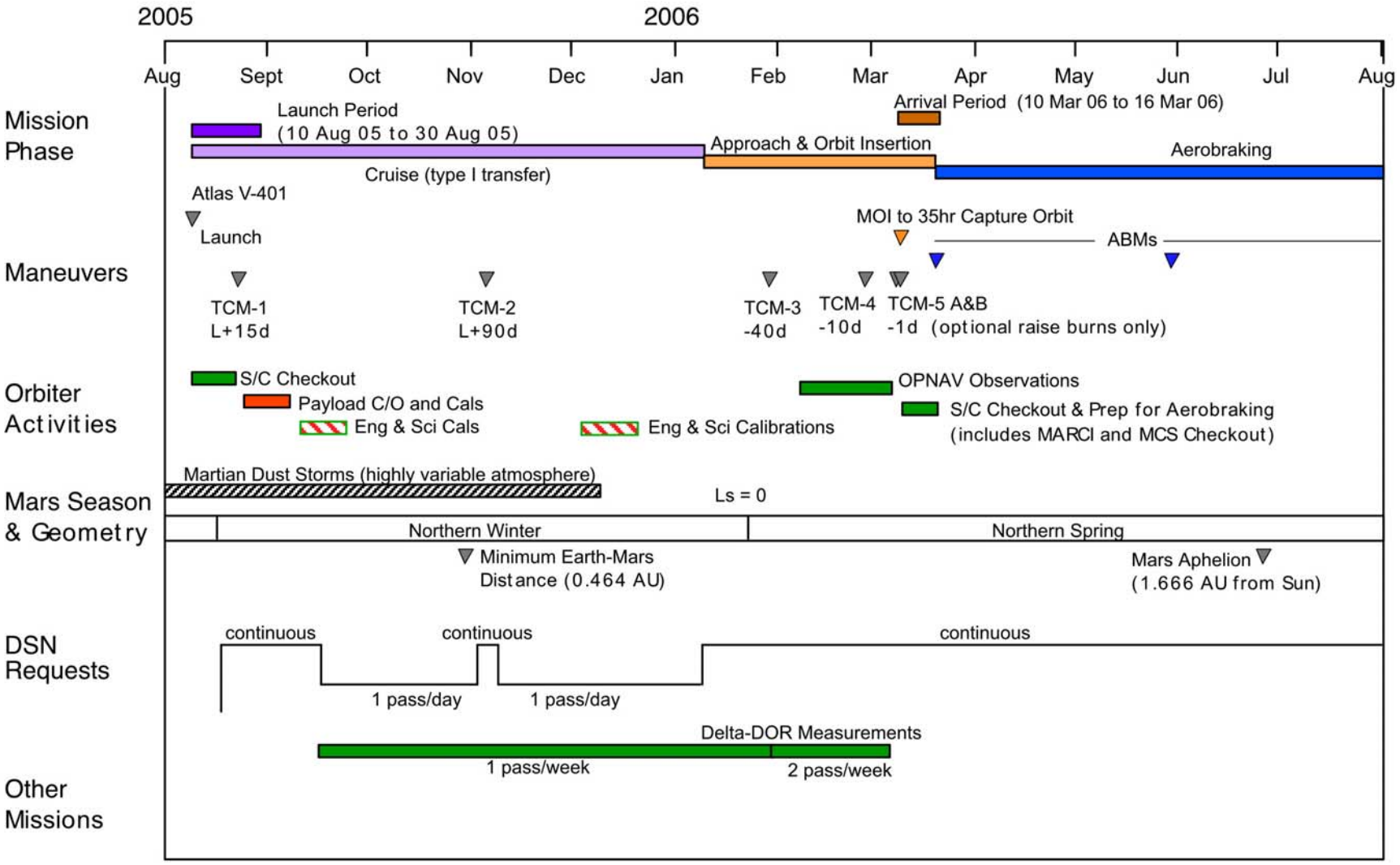
Primary Science/Relay
Dec 2006 - Dec 2010

Science Data
Acquisition/Return

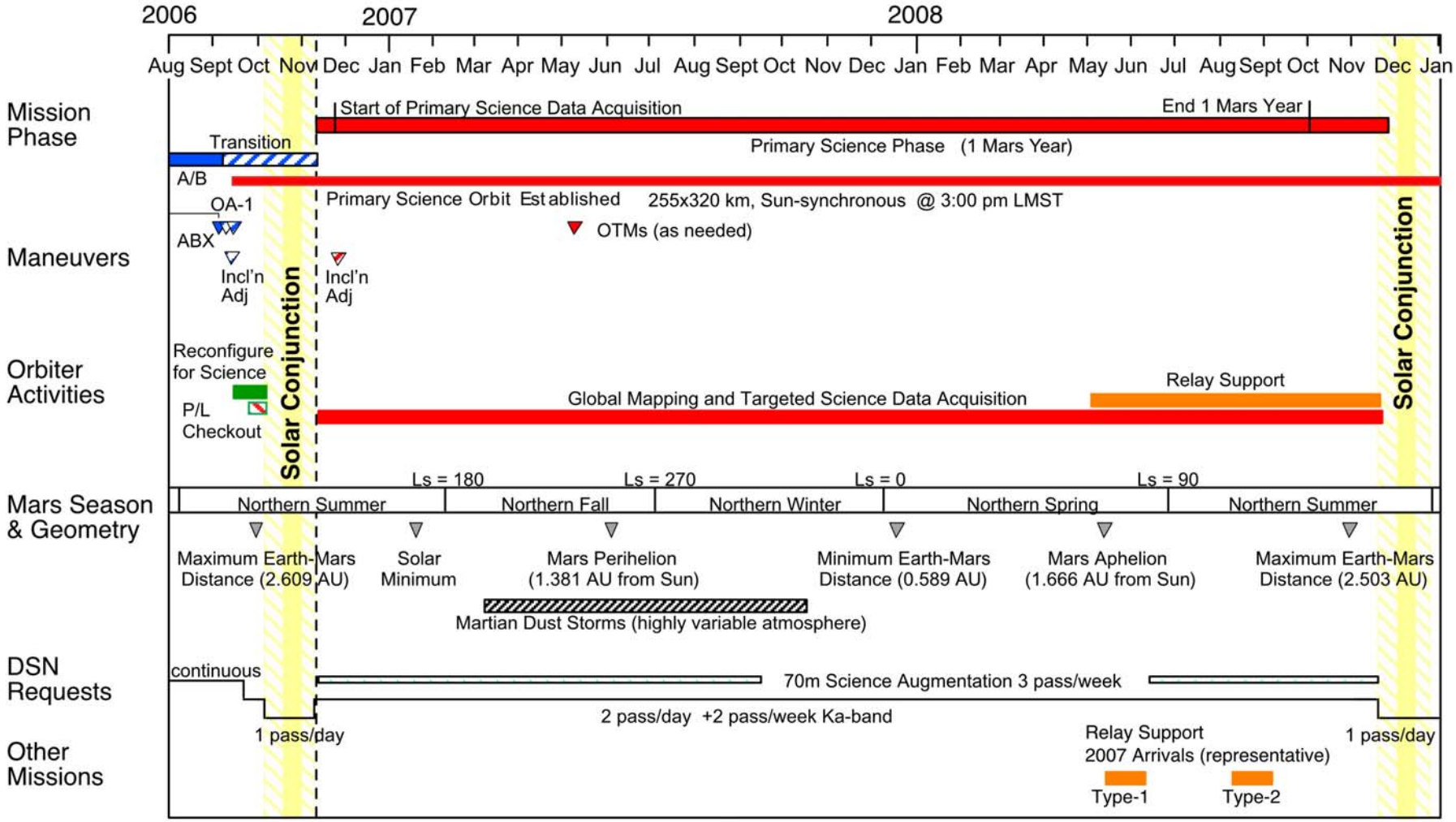


Primary Science/Relay Orbit ---
Period: 112 min
Hp: 255 km Ha: 320 km, Frozen
Ascending Node: 3:00 pm LMST (Sun-Sync)

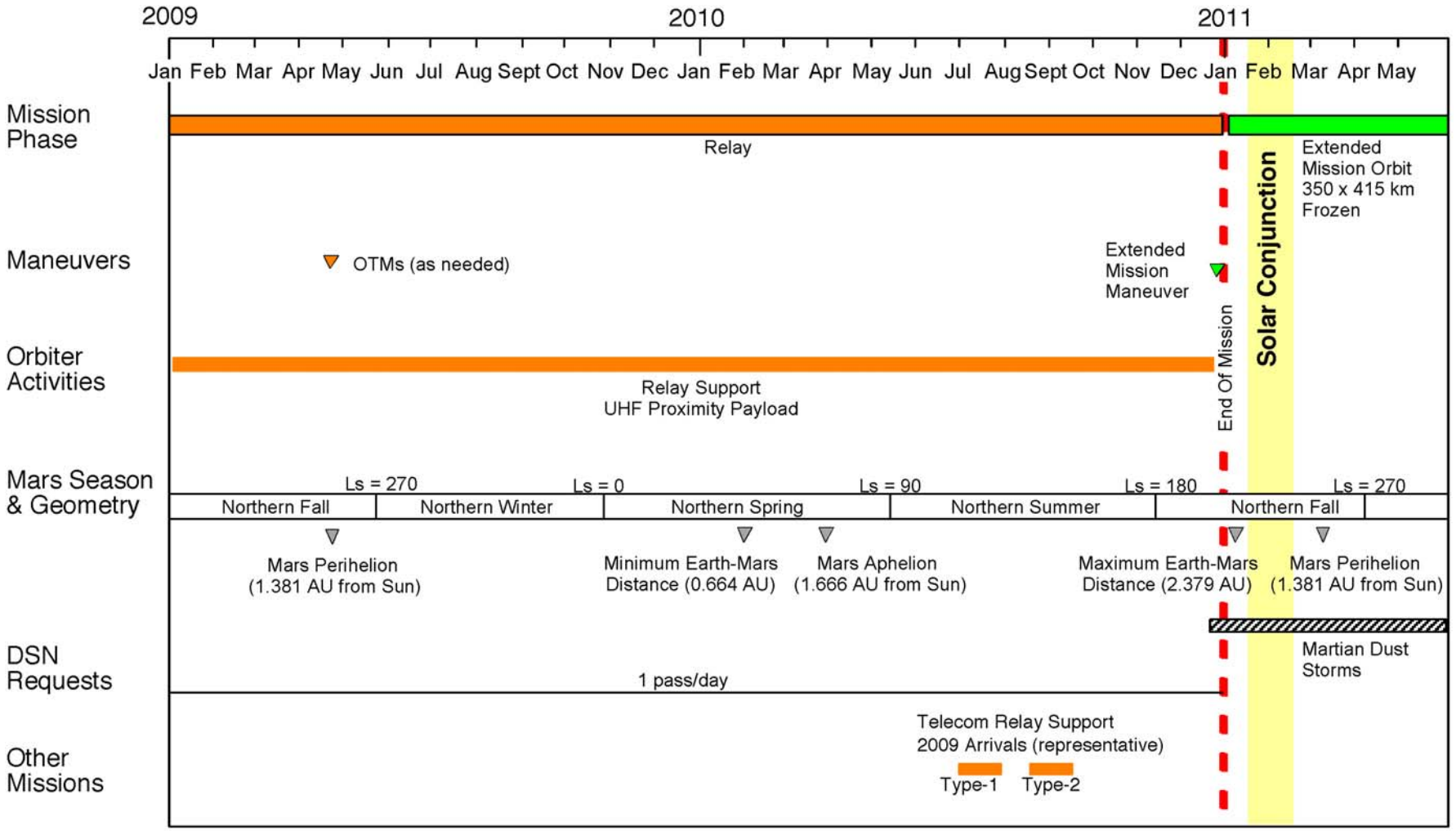
Mission Timelines (1/3)



Mission Timelines (2/3)

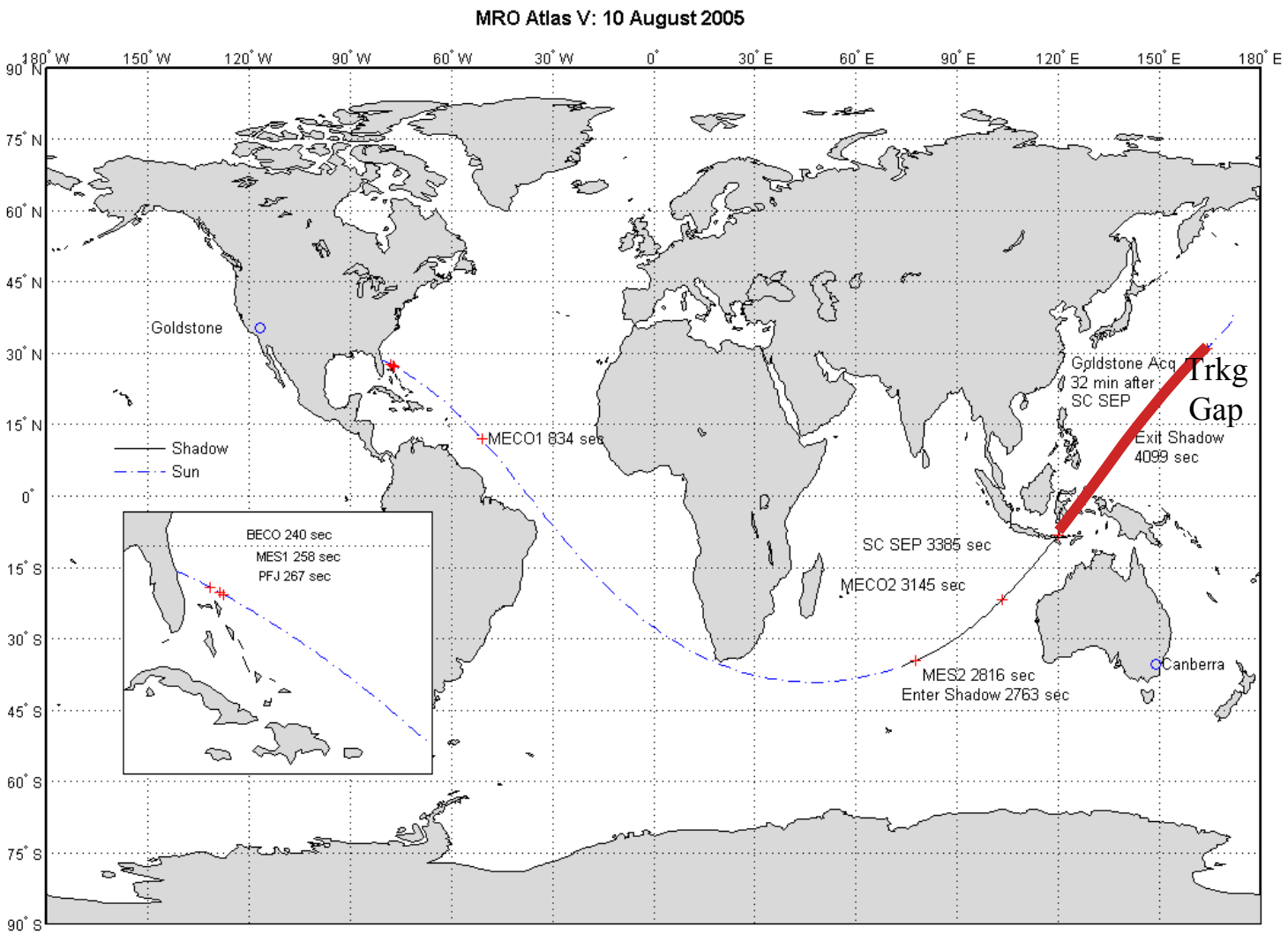


Mission Timelines (3/3)

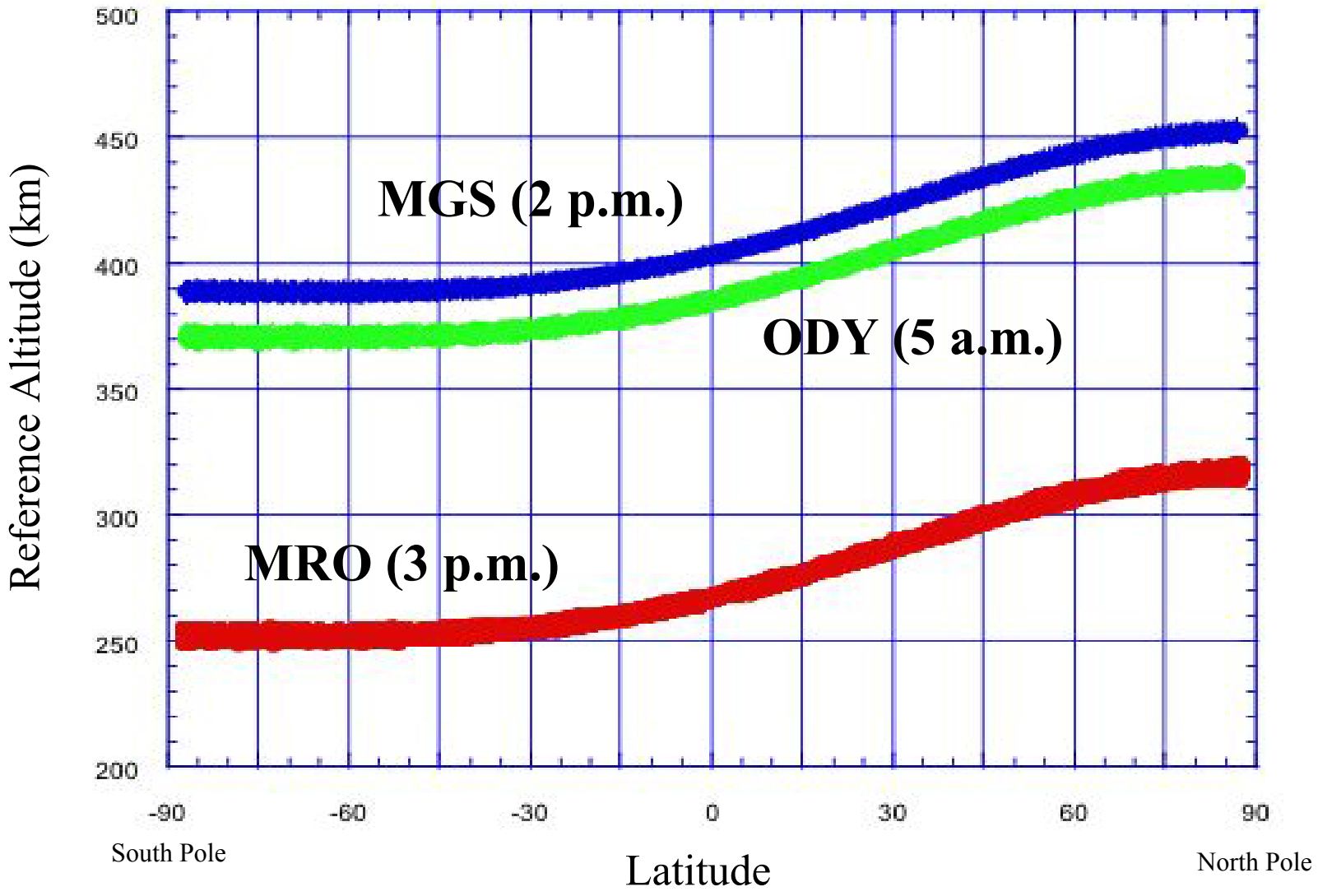


MRO Launch Groundtrack

- Launch Period:
  8/10 - 8/30/2005
  (21 days)
- Daily Launch Window:
  30 minutes (minimum)
- S/C TLM via Atlas-V until Separation
- Goldstone Rises 32 min after S/C Sep
- S/C deployments occur in the gap
- MRO desires TLM coverage in gap



Primary Science Orbits



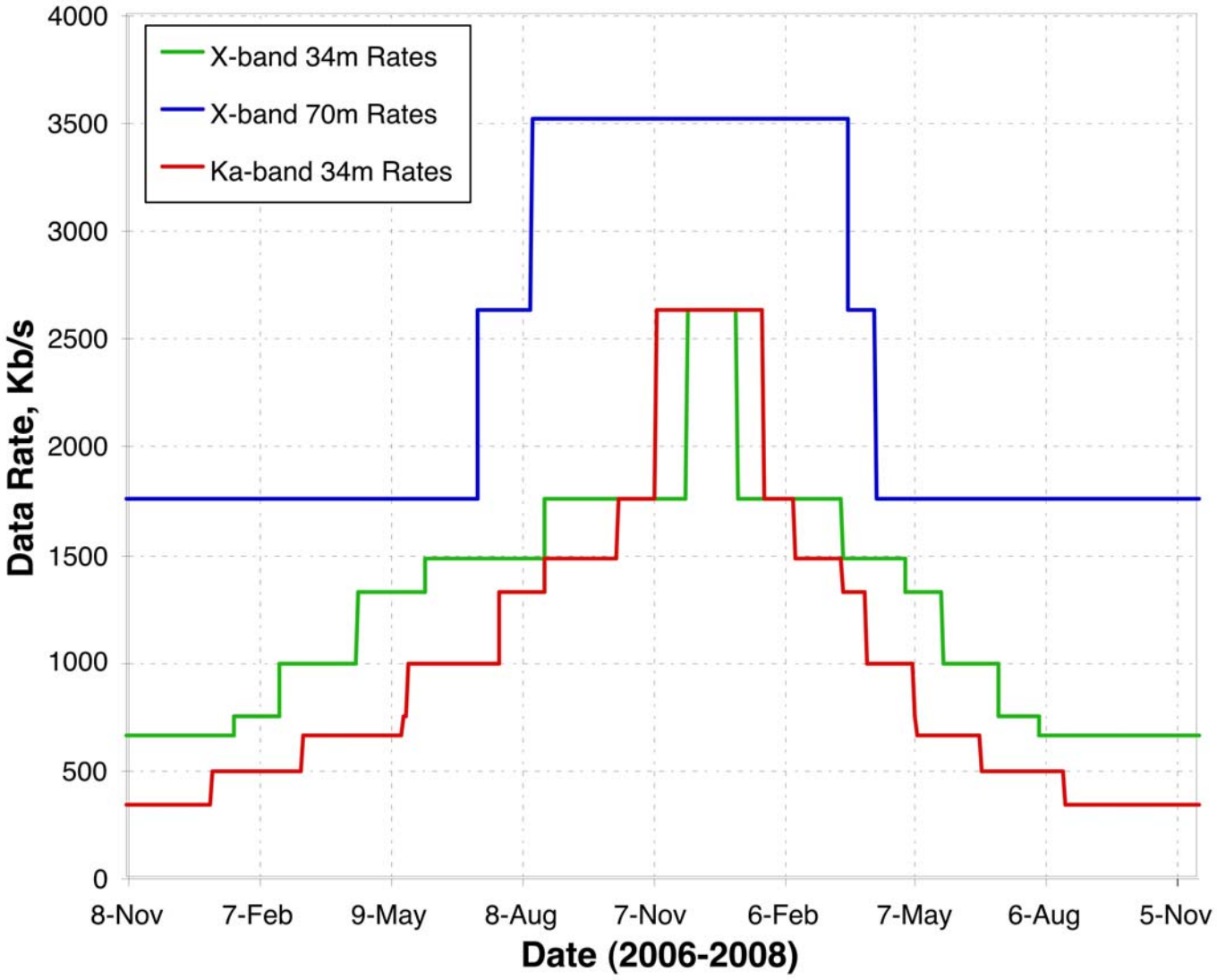
- ✓ ***Mixed Observation Modes during Science Phase:***
  - Global Monitoring throughout one Mars year (all seasons)
    - Daily and Seasonally: MARCI, MCS
    - Seasonally: CRISM (Atmospheric Mode), Tracking (Gravity)
  - Regional Surveys of Martian Surface and Subsurface
    - SHARAD, CTX, Tracking (Gravity)
    - Low Resolution Modes: CRISM, HiRISE
  - Targeted high spatial resolution observations
    - HiRISE, CRISM
    - Supported by CTX
  - Simultaneous Operations by Multiple Instruments
- ✓ ***Spatial resolutions unprecedented for Mars missions***
  - Enabled by instrument capabilities and mission design (orbit)
  - Spacecraft capabilities adequate to return required data volumes
    - Project Requirement ~ 34 Tbits
  - Data return capability determines areal coverage and number of sites observed at the highest spatial resolutions
- ✓ ***Coordinated observing for science & site characterization***

MRO Data Return Requirements

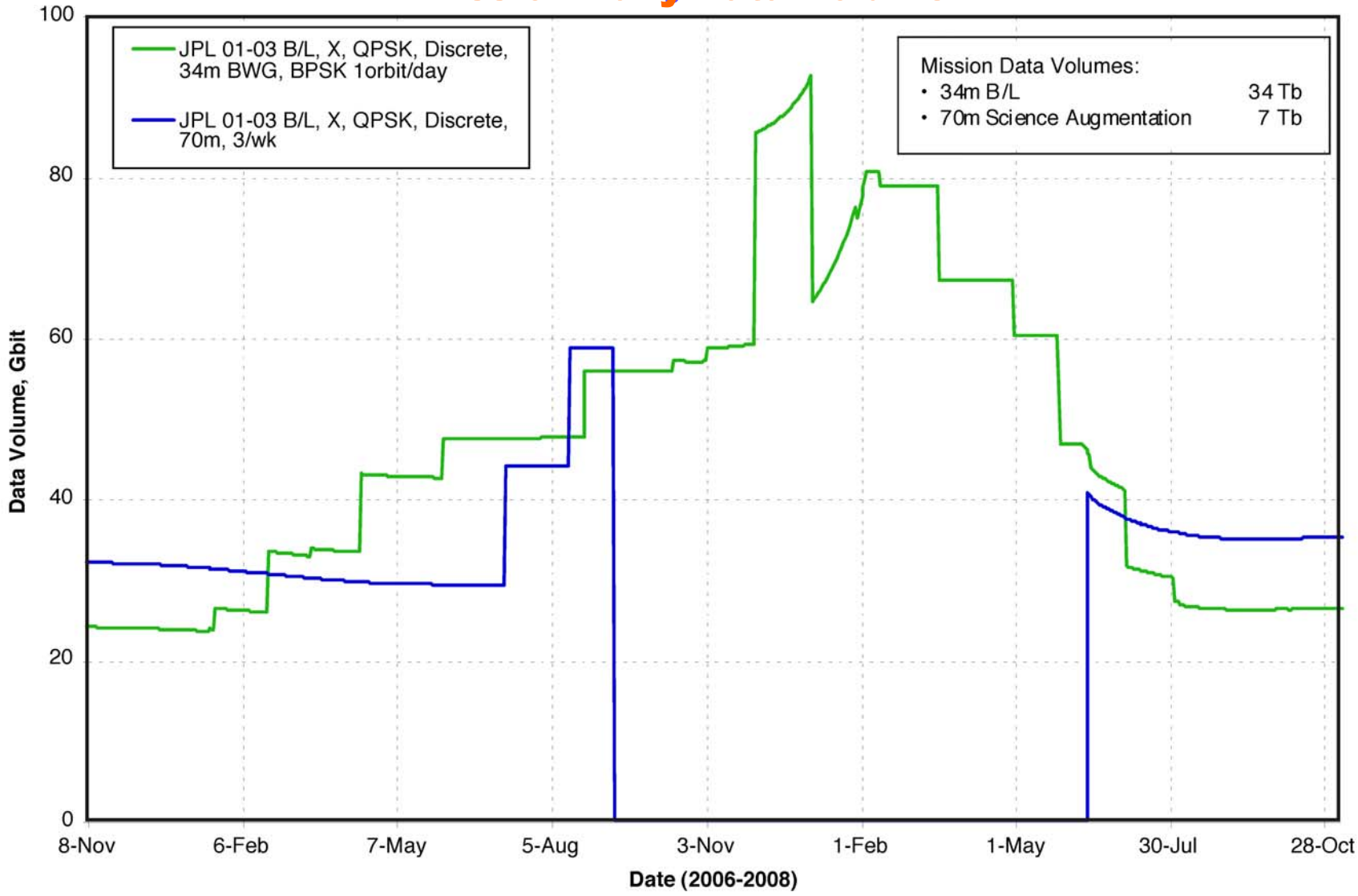
- ✓ ***Multiple Telecom Paths***
  - 2 daily X-band passes to 34-m antenna
  - 3 per week X-band passes to 70-m antenna except at peak
  - 2 per week Ka-band passes (34-m)
  - Project goal: Return 34 Tbits of science data in 1 Mars yr.
- ✓ ***Data Completeness***
  - 93% of data taken is successfully returned
    - **≤ 2 % loss on spacecraft**
- ✓ ***Retransmission capability for low data rate periods***
  - Assist data completeness requirement & data quality goal

Mission Data Rates - CDR

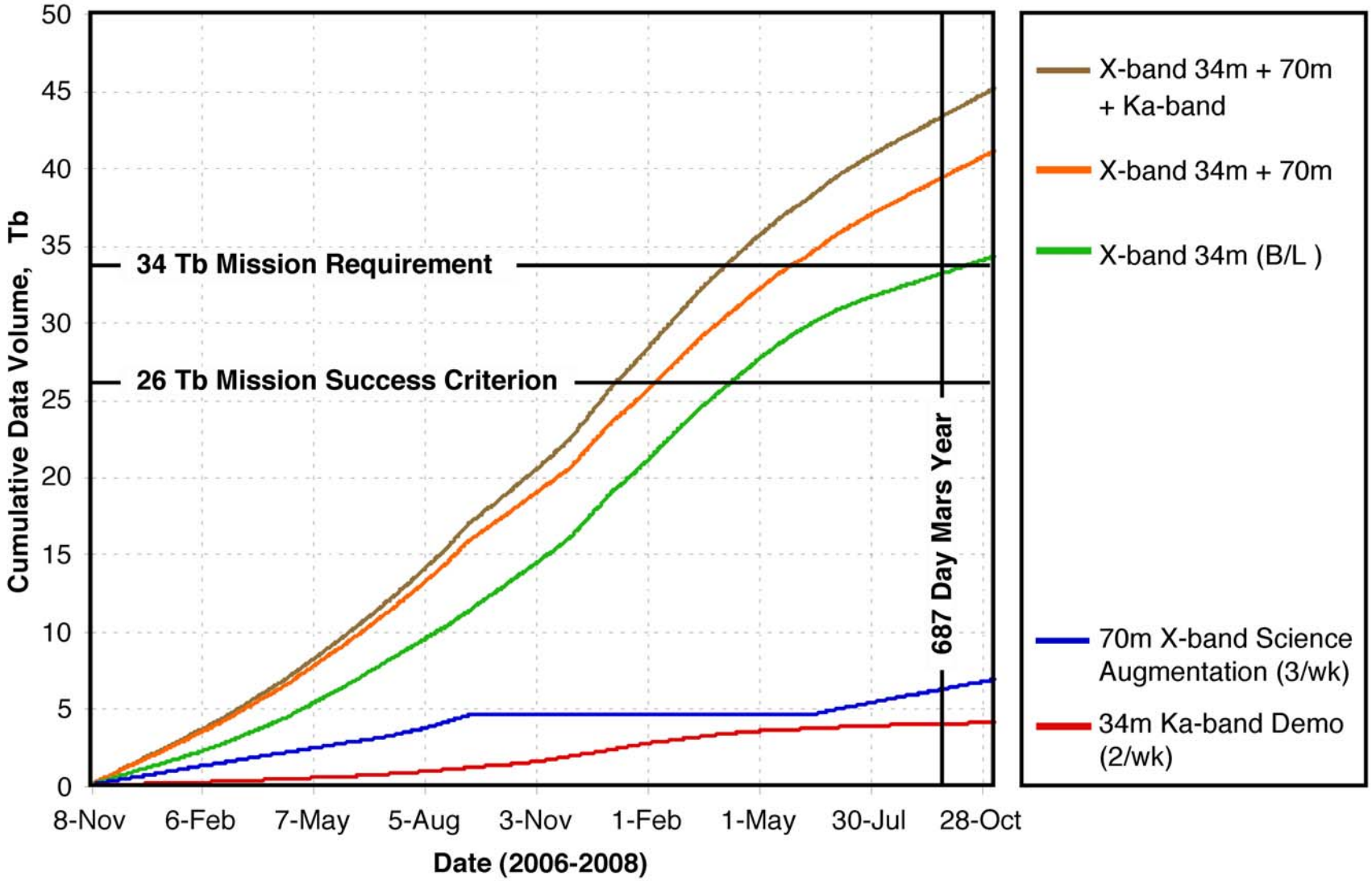
- Encoding Options
  - Reed-Solomon
  - R-S + Convolutional (k=7, rate 1/2)
  - Turbocodes (1/6, 1/3, 1/2)
- Constraints
  - 4MHz X-band Bandwidth
  - Turbocode decode limited to 1600 kb/s
  - Orbiter ULDL card limited to 6000 kb/s



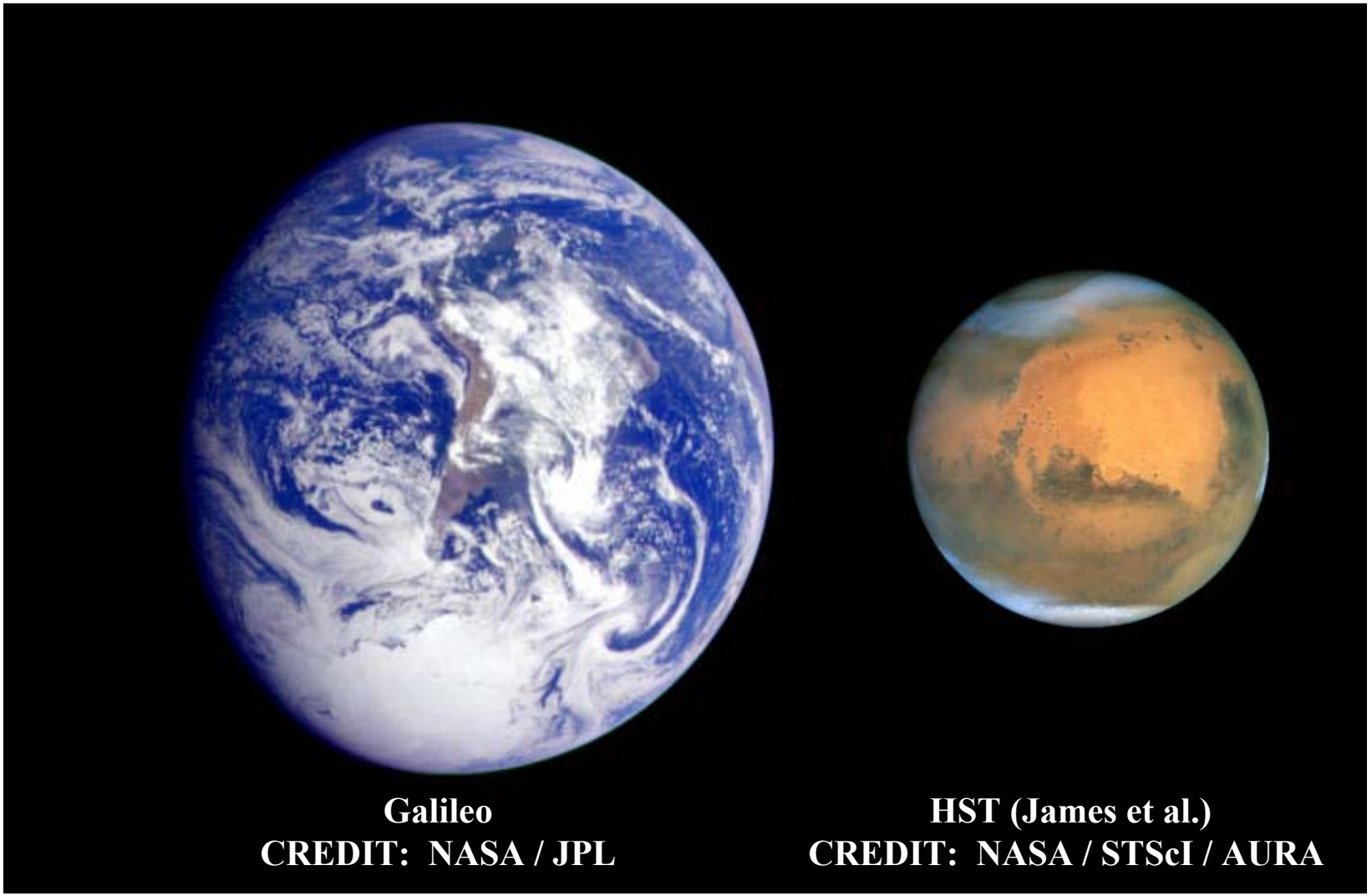
Mission Daily Data Volume



Cumulative Mission Data Volume



Earth & Mars



Galileo
CREDIT: NASA / JPL

HST (James et al.)
CREDIT: NASA / STScI / AURA

Mars Reconnaissance Orbiter (MRO)

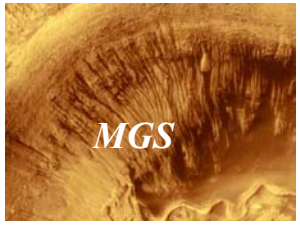
Salient Features

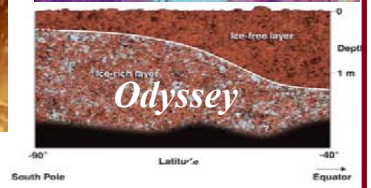
4 Earth years in Mars orbit (near polar, 3 p.m., 255 x 320 km)
- **2 years science observations plus relay support**
- **2 years relay mode with capability to extend science operations**

International Science Payload:
- **Meter- scale and context (6 m/pixel) imaging**
- **Hyperspectral (20 m, 10 nm) compositional mapping**
- **Atmospheric profiling and weather monitoring**
- **Radar probing of the near-subsurface; gravity science**

Relay Telecom Payload + Optical Navigation & Ka-Band Experiments

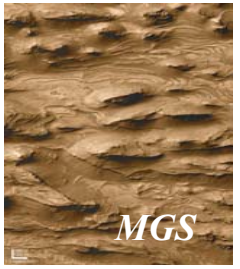
Launch: August 2005; Arrive: March '06; Aerobrake: Mar.- Oct '06; Mission End: Dec., 2010





Science

Characterize Mars' seasonal cycles and daily variations of water, dust & carbon dioxide.
Characterize Mars' global atmospheric structure, transport and surface changes.
Search sites for evidence of aqueous and/or hydrothermal activity.
Characterize in detail the stratigraphy, geology & composition of Mars surface features.
Characterize the Martian ice caps and the polar layered terrains.
Profile the upper crust while probing for subsurface water and ground ice.
Characterize the Martian gravity field and upper atmosphere in greater detail.
Identify and characterize many sites for future landed missions.



NEW OR MODIFIED PROJECT REQUIREMENTS

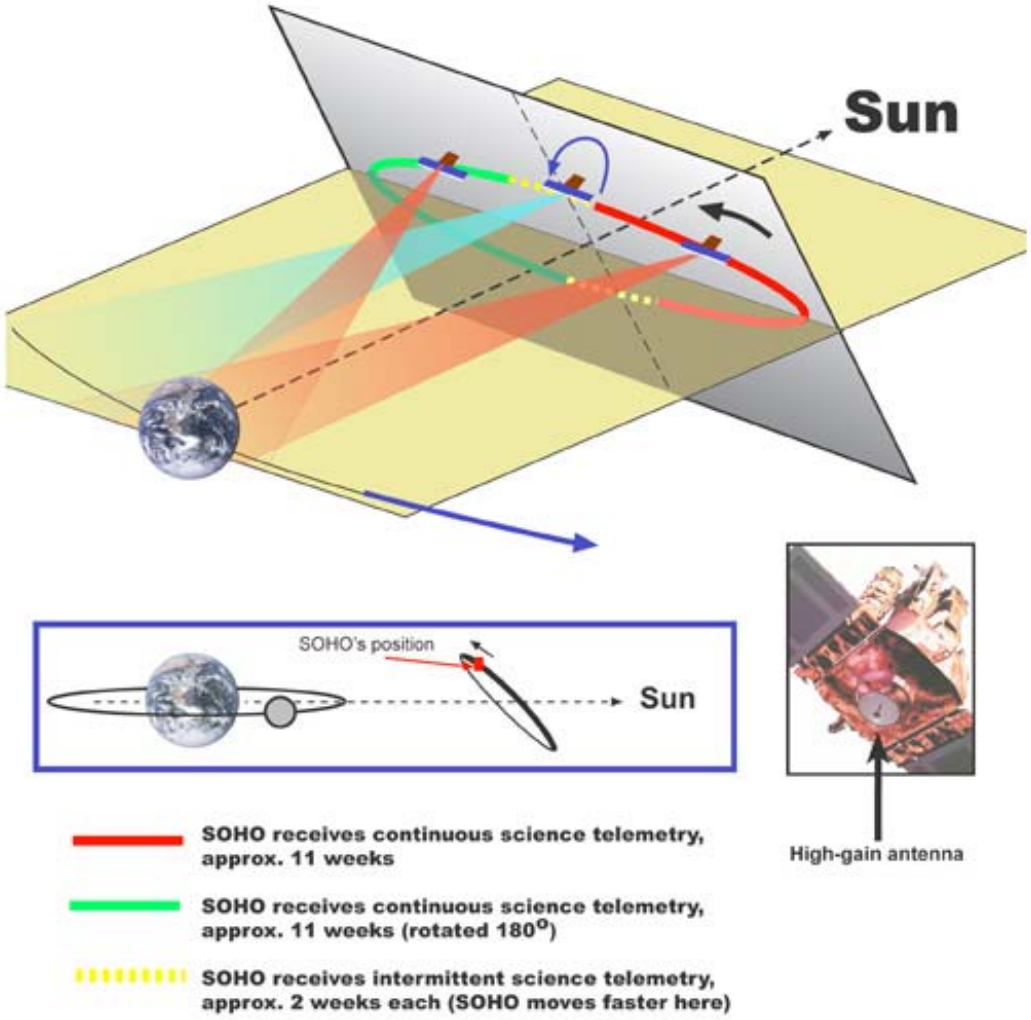
SOHO Requirements

R. Bush / R. E. Mahmot

Goddard Space Flight Center

SOHO High Gain Antenna Anomaly

- maximum HGA beam width on 26m stations: 8.9 deg
- maximum HGA beam width on 34m stations: 12.5 deg
- telemetry during zero crossings (yellow dotted line) using SOHO's Low Gain Antenna and 34 and 70m DSN stations



SOHO HGA Anomaly

- SOHO suffered problem with its High Gain Antenna (HGA) in May 2003 - East-West drive stuck
- Introduces science telemetry “keyhole” periods for 26m stations every 3 months, alternating between 18 and 25 days
- Larger 34 or 70m stations required to fill these “keyholes”
- During central 9 to 16 days of the keyholes, Low Gain Antenna (LGA) must be used to downlink science telemetry
- DSN support therefore to be classified into three types based on the achievable telemetry downlink rates using SOHO’s HGA or LGA on 26, 34, or 70m stations

3 Types of DSN Support

- Nominal Operations
  - High rate telemetry using the HGA on 26m stations
  - Covers approximately 9 to 10 weeks out of every 3 months
- High rate telemetry using the HGA on 34 or 70m stations
  - This covers the first and last 4 to 6 days of each keyhole period
  - 26m stations cannot lock on any telemetry rate during these periods.
- Medium rate telemetry using the LGA on 34m stations, and high rate telemetry using the LGA on 70m stations
  - This covers the central 9 to 16 days of each keyhole period
  - Recorder dumps can only be done during high rate telemetry (i.e., on 70m stations)

Why is it such a big deal?

- Helioseismology – study of the Sun's interior
  - Requires ***uninterrupted*** time series
  - g-modes search in particular would be severely compromised
- Total Solar Irradiance (TSI) measurements would also be severely compromised by extended and repeated gaps
- ESA therefore studying the feasibility of a Central OnBoard Software (COBS) patch, to optimize the use of the onboard Solid State Recorder
  - Will hopefully be available early 2004, but probably not for the December/January "keyhole"
- Loss of MDI high rate (in particular, also MDI magnetograms) without 70m support during central part of keyholes

Why is it such a big deal?

- **Space Weather**
  - Louis Lanzerotti (Chair NRC Decadal Survey "Solar and Space Physics")

    "The detailed data on solar phenomena, especially solar coronal phenomena such as coronal mass ejections, have been invaluable in providing entirely new insights to such solar emissions that can affect critical technologies on Earth and in the space environment around Earth. There is no replacement at the moment for any potential loss of solar imaging data from SOHO."

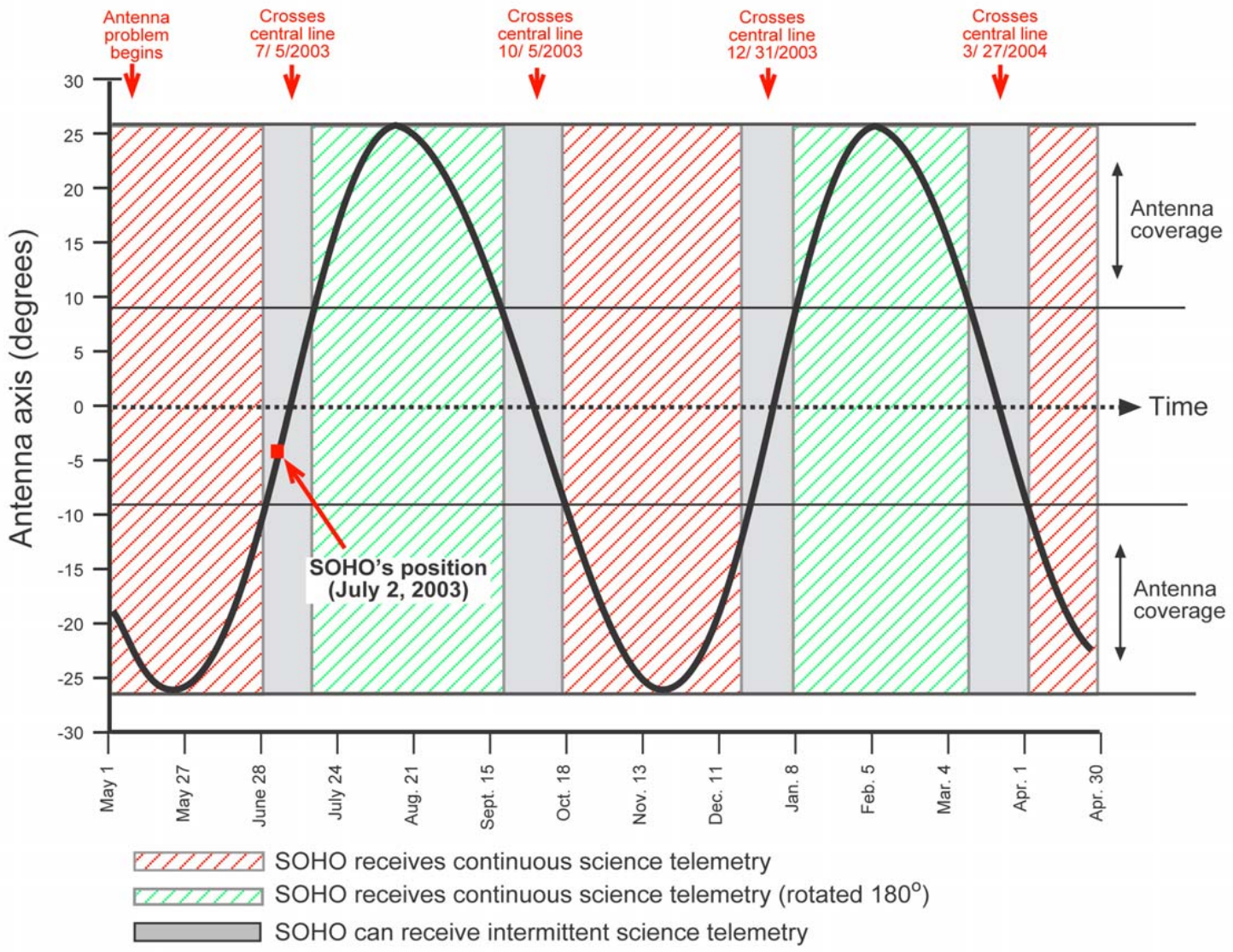
    (from Interview with Space.Com – 3 July 2003)

  - Joe Kunches (Lead Forecaster at the NOAA Space Environment Center)

    "It's hard to overstate the importance of that [SOHO] data," …
    and
    "I'm hopeful they'll be really resourceful and keep it coming in some fashion."
    If not, space weather forecasting "would be set back about 20 years."

    (from Interview with Space.Com – 19 June 2003)

Backup Chart


Antenna problem begins
Crosses central line 7/ 5/2003
Crosses central line 10/ 5/2003
Crosses central line 12/ 31/2003
Crosses central line 3/ 27/2004
Antenna axis (degrees)
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
Antenna coverage
Time
Antenna coverage
SOHO's position (July 2, 2003)
May 1
May 27
June 28
July 24
Aug. 21
Sept. 15
Oct. 18
Nov. 13
Dec. 11
Jan. 8
Feb. 5
Mar. 4
Apr. 1
Apr. 30
SOHO receives continuous science telemetry
SOHO receives continuous science telemetry (rotated 180°)
SOHO can receive intermittent science telemetry

New Action Items / Summary

E. S. Burke

JPL

Resource Allocation Review
2005 - 2014
TIMELINE FOR NEXT REVIEW
February 10, 2004

Calendar Date	Milestones
October 21, 2003	Distribute Mission Set, Major Events and User Loading Profiles to Projects/Users for verification.
November 18, 2003	Deadline for Projects/User's responses to Mission Set, Major Events, and User's Loading Profiles; and last day for trajectory or viewperiod updates or submissions.
January 14, 2004	NASA Headquarters Science Review
January 20, 2004	Publish preliminary Contentions and Recommendations on the RAPWEB for Projects/User's review.
January 27, 2004	Complete the review of RAPWEB published contentions with Projects/Users
February 10, 2004	Resource Allocation Review